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NOVEMBER 1930

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PUBLISHED MONTHLY BY THE
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 WEST 39TH ST· NEW YORK CITY

FUTURE MEETINGS

of the

American Institute of Electrical Engineers

Place	*Dates*	*Nature*	*Latest Date for Receipt of Manuscripts*
Louisville, Ky.	Nov. 19-22, 1930	District Meeting	(Closed)
New York, N. Y.	Jan. 26-30, 1931	Winter Convention	(Closed)
Pittsburgh, Pa.	March 11-13, 1931	District Meeting	Dec. 11, 1930
Rochester, N. Y.	May 6-9, 1931	District Meeting	Feb. 6, 1931
Asheville, N. C.	June 22-26, 1931	Summer Convention	March 23, 1931
Lake Tahoe, Cal.	Aug. 25-28, 1931	Pacific Coast Convention	May 25, 1931
Kansas City, Mo.	Oct. 22-24, 1931	District Meeting	July 22, 1931

NOTE: Members who are contemplating submitting papers for presentation at any of the above meetings should communicate promptly with Institute headquarters, 33 West 39th Street, New York, N. Y., so that their papers may be docketed for consideration by the Meetings and Papers Committee, as programs for all meetings are formulated several months in advance. Upon receipt of this notification, Institute headquarters will mail to each prospective author information in regard to the Institute's rules relating to the preparation of manuscript and illustrations.

MEETINGS OF OTHER SOCIETIES

National Research Council, Committee on Insulation. Bureau of Standards, Washington, D. C., November 7, 1930. (Dr. J. B. Whitehead, Johns Hopkins University, Baltimore, Md.)

Naval Architects & Marine Engineers, Engineering Societies Building, 33 West 39th Street, New York, N. Y., November 13-14, 1930. (Daniel H. Cox, Secretary-Treasurer, 33 West 39th Street, New York, N. Y.)

New York Electrical Society in Joint Meeting with New York Section of A. I. E. E. and Museum of Peaceful Arts, Mecca Temple, 133 West 55th Street, New York, N. Y., November 19-20, 1930. (F. M. Delano, Secretary, 29 West 39th Street, New York, N. Y.)

The American Physical Society, Regular Meeting, Ryerson Physical Laboratory, Chicago, Illinois, November 28-29, 1930. (W. L. Severinghaus, Secretary, Columbia University, New York, N. Y.) also at Los Angeles, Dec. 12-13, 1930.

The American Society of Mechanical Engineers, Annual Meeting, Engineering Societies Building, 33 West 39th Street, New York, N. Y., December 1-5, 1930. (Calvin W. Rice, Secretary, Engineering Societies Building, New York)

Midwest Power Engineering Conference, Chicago, Illinois, February 10-13, 1930. (G. E. Pfisterer, 308 W. Washington St., Chicago, Illinois)

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Institute and Related Activities

A REQUEST FOR CHANGE OF ADDRESS must be received at Institute headquarters at least ten days before the date of issue with which it is to take effect. Duplicate copies cannot be sent without charge to replace those issues undelivered through failure to send such advance notice. With your new address, be sure to mention the old one indicating also any changes in business connections.

(The Journal of the A. I. E. E. is indexed in Industrial Arts Index.)

American Institute of Electrical Engineers

—Some Activities and Services Open to Members—

Presentation of Papers. An important activity of the Institute is the preparation and presentation of papers before meetings of the Institute. Opportunity is offered for any member to present a paper of general interest to engineers at an Institute meeting, or of having shorter contributions published in the Journal without verbal presentation. In preparing a paper for presentation at a meeting, the first step should be to notify the Meetings and Papers Committee about it so that it may be tentatively scheduled. Programs for the meetings are formulated several months in advance and unless it is known well in advance that a paper is forthcoming, it may be subject to many months' delay before it can be assigned to a definite meeting program. Immediately upon notification, the author will receive a pamphlet entitled "Suggestions to Authors" which gives in brief form instructions in regard to Institute requirements in the preparation of manuscripts and illustrations. This pamphlet contains many helpful suggestions and its use may avoid much loss of time in making changes to meet Institute requirements.

Manuscripts should be in triplicate and should be sent to Institute headquarters at least three months in advance of the date of the meeting for which they are intended; they are then submitted first to the members of the Technical Committee covering the subject of the paper, and if approved, will next go to the Meetings and Papers Committee for final disposal. After final acceptance, the paper goes to the Editorial Department for printing, which requires usually from two to three weeks. Advance copies are desired about ten days prior to the meeting in order to distribute the paper to members desiring to discuss it. Considering the routine through which all papers must pass, the advantage of prompt notification and early submitting of manuscripts will be apparent.

Scope of Papers.—Institute papers should present information which adds definitely to the theoretical or practical knowledge of electrical engineering and may be derived from activities in any of its branches. Acceptable subject matter is as follows: New theories or new treatments of existing theories; Mathematical solution of electrical engineering problems; Researches, fundamental or practical; Design of equipment, and of electrical engineering projects; Engineering and economic investigations; Operation and tests of electrical equipment or systems; Measurements of electrical quantities; Electrical measurement of non-electrical quantities; Applications of electricity to industrial or social purposes; Education; Standardization; Cooperative engineering organizations; Ethical and social aspects of the profession.

The Winter Conventions are usually the outstanding technical meetings of each year and are held in the eastern section of the country, generally in New York City. The programs consist chiefly of technical sessions which occupy practically all the available time of a five-day meeting, except one day which is set aside for inspection trips to engineering works of interest in the neighborhood of the convention city. Aside from the entertainment provided for ladies in attendance, the only social function is a dinner-dance held on one evening during the convention. The Winter Conventions have been described as the "working conventions" of the Institute because the social and entertainment features are almost entirely subordinated to the consideration of technical papers.

Library Service.—The Engineering Societies Library is the joint property of the four national societies of Civil, Mining, Mechanical, and Electrical Engineers and comprises one of the most complete technical libraries in existence. Arrangements have been made to place the resources of the library at the disposal of Institute members, wherever located. Books are rented for limited periods, bibliographies prepared on request, copies and translations of articles furnished, etc., at charges which merely cover the cost of the service. The Director of the library will gladly give any information requested as to the scope and cost of any desired service. The library is open from 9 a. m. to 10 p. m. every day except holidays and during July and August, when it closes at 5 p. m.

Abridgment of

Outdoor Switching Equipment
at Northwest Station Commonwealth Edison Company, Chicago, Illinois

BY W. F. SIMS[1] and C. G. AXELL[2]

Member, A. I. E. E. Associate, A. I. E. E.

Synopsis.—*This paper describes the switching equipment and its arrangement in an outdoor switching center at 132, 66, and 12 kv., in connection with an installation of three-winding transformers, This installation is a junction point on an interconnected system, from which energy is distributed at the lower voltage.*

The development of the original 12-kv. installation with indoor type of equipment enclosed in metal housings and concrete cells is described and the reasons leading to its extension with metal-clad oil filled gear are discussed.

A feature of this metal-clad oil filled installation is that it is laid out on an isolated phase basis with wide separation between phases, which is the first time that this arrangement has been attempted with this type of equipment.

Included in the design are complete facilities for grounding and testing of the equipment, which to insure maximum safety in their use are fully interlocked.

A brief discussion of costs as compared with indoor installations is also given.

General

When the installation of the first 132-kv. underground cable to the Northwest Station of the Commonwealth Edison Company was planned, as a part of the interconnection of systems in the Chicago area, the design of suitable terminal arrangements became an important problem.

Studies of the problems involved resulted in the development of an outdoor installation with equipment to serve three different voltages—namely, 132, 66, and 12 kv.—of size sufficient to meet the present demands and to provide space for additional equipment for future needs at all three voltages. The terminal was designed on the isolated-phase basis with double busses on both the 66- and 12-kv. portions.

Fig. 1 shows the arrangement of this terminal with the present equipment, together with the space available for future extension.

132-Kv. Installation. On the basis of calculated three-phase instantaneous short-circuit conditions, a rated interrupting rating of 1,500,000 kv-a. at 154 kv. was specified. Each breaker consists of three outdoor single-pole, 600-ampere, wheel-mounted tanks, each provided with a separate solenoid operated mechanism both mechanically and electrically trip-free. The three poles are only electrically interlocked, with the operating coils connected in parallel. All disconnective switches are made up of three single-pole motor-oper-

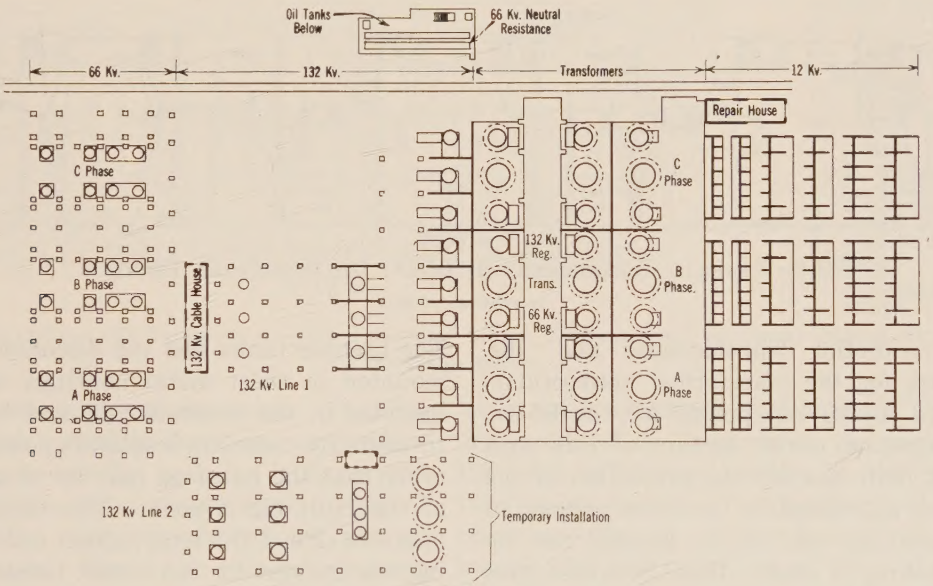

Fig. 1—General Arrangement of Outdoor Terminal
Northwest Station

1. Asst. Engineer, Inside Plant, Commonwealth Edison Company, Chicago.
2. Engineer of Electrical Design, Commonwealth Edison Company, Chicago.

Presented at the Middle Eastern District Meeting No. 2, Philadelphia, Pa., October 13-15, 1930. Complete copy upon request.

ated elements, connected in parallel for simultaneous operation. Motor-operated grounding switches are installed for grounding the lines and transformers, with the control circuits so arranged that each phase will be grounded separately. These are both mechanically and electrically interlocked with the corresponding disconnective switches so that neither can be closed unless the other is fully open.

66-Kv. Installation. As shown in Fig. 2, the switch yard is divided into three zones, each 54 ft. wide and containing the equipment for one phase.

The layout of the 66-kv. busses is on the isolated-phase basis with a main and an emergency bus. Each bus is divided into two sections so as to conform to the general scheme of sectionalizing of the system.

For each phase, the structure is in three parts, with solidly grounded double metal screen barriers between adjacent phases for the entire length of the structure, to prevent any possible flashover between phases. The central part, insulated from ground, supports the busses and connections and is not tied in with the two outer parts. These two parts are both grounded. On one part are mounted the 66-kv. cable potheads, potential transformers, and disconnective switches for the transformer connections; the other supports similar equipment for the 66-kv. lines. The underground center section of this steel work is used as a fault bus for the protection of the 66-kv. busses and disconnective switches connected thereto. The operating coils are in parallel and no mechanical interlocking is used. These breakers have a rated interrupting capacity of 1,000,000 kv-a. at 66 kv. Due to the use of a 30-ohm neutral resistor, the possible voltage will be on the order of 76-kv. This determined the selection of 88-kv. breakers, which is the manufacturer's rating nearest above this value. Only one three-phase oil circuit breaker is installed for each transformer and for each line, the connections between these breakers and the busses being made through two sets of selector disconnective switches. For each phase, these single-pole breakers are arranged in two rows located between the main and emergency busses. Also with this arrangement, no extra insulator supports are required for the busses as the selector disconnective switch insulators installed horizontally on the top of the structure serve that purpose. All disconnective switches are made up of three single-pole motor-operated elements with the motors connected in parallel. Those for the lines and transformers are equipped with a motor-operated grounding blade insulated for 7500 volts and are individually operated. They are mechanically and electrically interlocked with the main blades.

12-Kv. Metal Housed Installation. The first installation, which used a standard type of indoor breaker installed in a metal housing provided for two 60,000-kv-a. banks of transformers, four 12-kv. distribution lines, and two tie lines to the indoor 12-kv. busses. The scheme of connections follows the usual layout in all of the generating stations of the company. This provides for two main busses with line busses accommodating four distribution lines each, connected through group breakers to the main busses with circuit breakers for connecting the transformers to either of the main busses. For the lines, 600-ampere breakers are used; 2000-ampere for the group switches; and 3000-ampere for the transformers and tie lines. This corresponds to the phase segregation in the 66-kv. switch yard. Fig. 3 shows the general arrangement.

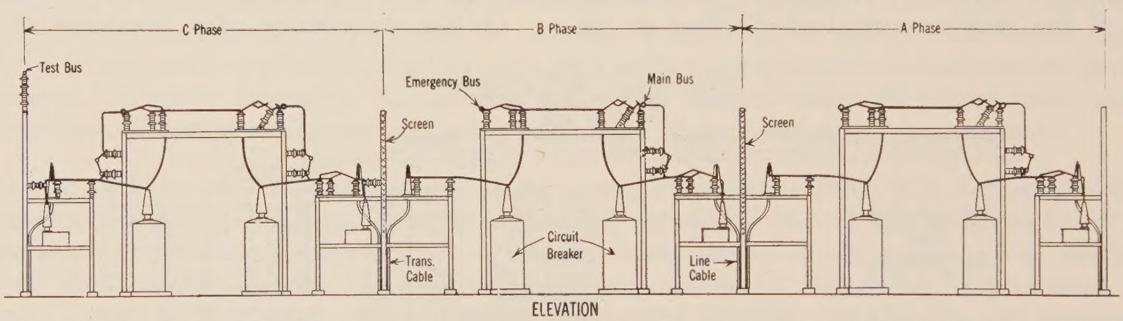

Fig. 2—General Arrangement of 66-kv. Isolated-Phase Terminal

Northwest Station

The breaker tanks and the disconnective switches are mounted in sheet metal housings of ⅛-in. thickness installed in the concrete cells and insulated from the concrete by porcelain insulators good for 7500 volts, in order that the housings may serve as an integral part of the fault bus system. The compartments on the opposite side of the longitudinal wall house the operating mechanisms for the circuit breakers and the motor operated disconnective switches. The test and ground busses, with the necessary selector knife switches for grounding and testing, also are installed in these compartments. The mechanisms for the oil circuit breakers and the disconnective switches are mechanically interlocked to prevent improper operation, and the selector knife switches for grounding and testing are interlocked with the disconnective switches. To prevent condensation, space heaters are installed in all compartments. Reactors of the outdoor type for the lines and transformers are mounted on the top slab of the structure. Circuit breakers of the indoor type, having a rated interrupting duty of 800,000 kv-a. at 12 kv., and insulated for 25,000 volts, were selected. This voltage rating, which was also used for the bus and discon-

nective switch insulators, was chosen in order to obtain a high margin of safety. Each three-phase breaker consists of three single-pole units installed on 50-ft. centers with separate mechanically trip-free mechanisms, the solenoids of which are connected in parallel for simultaneous operation. The breaker tanks may be withdrawn from the housings on to a transfer truck with a motor-operated winch. A repair house located adjacent to this installation and equipped with a hoist and oil piping connections affords the necessary maintenance facilities. The design of this installation included complete facilities for the grounding and testing of all 12-kv. busses, transformer leads, tie lines, distribution lines and circuit breakers. By means of lever-operated knife switches in connection with the disconnective switches, the desired equipment can be connected for either grounding or testing. For this operation the disconnective switch when in the open position can be changed from motor to hand operation for further movement to the test or ground position. The operation is completely interlocked to prevent improper operation. Installation is equipped with complete fault bus protection. That there may be no parallel path for fault current to flow to ground, all housings are completely insulated from ground excepting where predetermined ground connections are made. For this reason, insulated sections were installed in the conduit for all wiring entering the housings. The sheet metal covers of the main bus compartments also form a part of the fault bus which is so sectionalized that in the event of a fault, a minimum of equipment will be taken out of service.

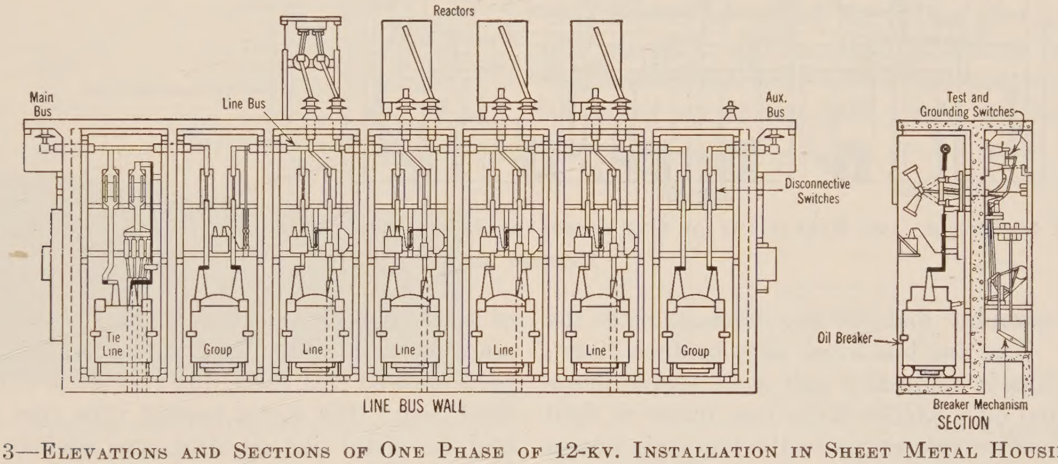

Fig. 3—Elevations and Sections of One Phase of 12-kv. Installation in Sheet Metal Housings
Northwest station

12-Kv. Metal-Clad Oil Filled Installation. This project differs from other metal clad installations in several particulars: It is the first installation of this type built with the isolated-phase arrangement, and the breakers are withdrawn horizontally instead of being lowered; this feature greatly simplifies the design. The oil field line busses are supported on a concrete wall which also supports the line reactors and the grounding and testing equipment. In addition, there is included in this project an installation of four circuit breakers for transformer connections installed in open concrete compartments with open type copper bar connections to the main busses. The oil filled equipment has been installed as a continuation of the original 12-kv. installation and the general layout is along similar lines. Transverse concrete walls, 7 ft. 8 in. in height, for supporting the oil filled line busses and equipment, are installed across the space between the main bus walls. Concrete barriers forming six compartments in which the 12-kv. cable terminals, the oil filled cabinets containing the testing and grounding switches, and the potential transformers are installed have been built at the rear of these walls. Fig. 4 shows a section and elevation of this arrangement. In contrast with the original 12-kv. outdoor installation, outdoor type of equipment is used. The breakers selected have a rated interrupting duty of 900,000 kv-a. at 12 kv. Each three-phase breaker consists of three truck-mounted single-pole units installed on 50-ft. centers, each equipped with a solenoid operated mechanism which is both mechanically and electrically trip-free. The mechanisms are mounted in sheet-metal housings supported on the truck with space heaters in the housings to prevent condensation. The breaker and wheel-mounted truck assembly is of the horizontal draw-out type, installed on rails which are an integral part of the rigid frame work, insulated from ground, and on the upper part is supported a sheet metal housing enclosing the stationary bushings and contacts with which the contacts on the bushings of the circuit breaker are engaged. The breaker mechanism is so interlocked that the breaker cannot be withdrawn or replaced unless it is in the open position. Self-alining contacts are used on the bushings of all circuit breakers for engaging the clip on the stationary contacts. The scheme of connections of the knife-blade switches for testing and grounding is similar to that previously described in the original 12-kv. installation excepting for necessary modifications due to the absence of separate disconnective switches at the circuit breakers. These switches are enclosed in oil filled metal cabinets mounted on the

rear of the structure behind the oil breakers. A disconnective switch to which the line cable is connected is also mounted in each cabinet in connection with the line breakers. This equipment is fully interlocked so that these switches cannot be moved while the oil circuit breaker is open and the breaker cannot be closed unless these switches are in the proper position. The interlock also prevents their operation unless the line disconnective switch is open. Cable potheads are bolted to the bottom of these cabinets through which the 12-kv. single-conductor line cables are brought for connection to the line disconnective switches. The oil filled line bus assembly consists of a copper bus inclosed in copper tubing with aluminum alloy connecting boxes, the oil conservator and the primary disconnective bus contacts. This assembly is divided into three sections; the line bus assembly and the two connections to the main busses. The line bus which supplies four 12-kv. distribution lines is made as a unit with flexible joints and is mounted on a welded angle iron frame of rigid construction. The connections to the two main busses are in separate aluminum alloy boxes. These three sections are insulated from the concrete supporting structure and from each other and form parts of the fault bus system. The oil is carried to the system through connecting pipes with suitable valves and insulating couplings. The line bus is made up of sections of hard drawn copper tubing 3½ in. in diameter with a carrying capacity of 2000 amperes. The current limiting reactors for the 12-kv. lines which are of 450-ampere capacity and ½-ohm reactance are of the air-core metal-clad, oil immersed type, with connections brought out at the bottom of the tank. Each reactor tank serves as an oil conservator for the testing and grounding switch cabinet. Reference has been made to circuit breakers for two transformer banks installed in connection with this project, these are not of the oil filled type. This arrangement was made because the carrying capacity required in their connections is such that a satisfactory design of oil filled equipment could not be worked out. This was also the case with the main busses. These breakers and their disconnective switches are of the outdoor type installed in concrete compartments similar to the original 12-kv. installation excepting that metal houses are omitted.

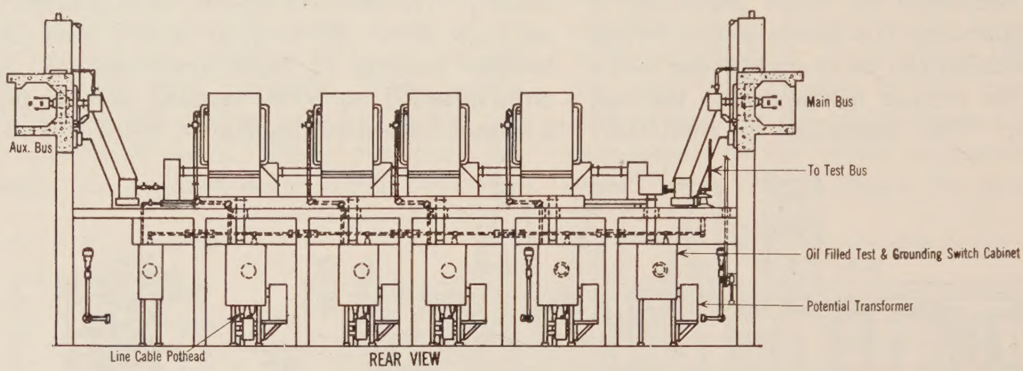

Fig. 4—Section and Elevations of One Phase of 12-kv. Metal Clad, Oil Filled Installation
Northwest Station

Conclusion

The metal housed equipment has been in service for about three years and the metal clad oil filled, for about eight months. So far the operating experience with both installations has been entirely satisfactory, and with the possible exception of maintenance difficulties under severe weather conditions, it is fully as convenient of operation as an indoor installation.

Preliminary estimates had indicated the possibility that a 12-kv. outdoor installation should cost less than one indoors, with the cost of building included. Exact comparisons are difficult to make because of varying conditions on different projects. However, an analysis of actual cost figures of both kinds of installations with allowances made to place their costs on a comparable basis showed that there was very little difference in the final cost. The metal housed type cost slightly less, and the metal clad oil filled type slightly more than a standard indoor isolated phase installation.

NEW HIGH-SPEED CUTTING MATERIAL

A new substance known as tungsten-carbide which offers great possibilities for high-speed cutting was described by W. H. McCoy of the General Motors Corporation of the Production Meeting of the Society of Automotive Engineers held October 7th and 8th at the Book-Cadillac Hotel, Detroit.

The new material is in the form of an iron-gray powder of minute cubical crystals which can be briquetted with cobalt and used for high-speed cutting tools. Tungsten-carbide is made by carbonizing incandescent tungsten in methane or hydrocarbon vapor. It is then molded into a form suitable for attaching to the cutting end of a tool. As it is almost as hard as diamonds, cutting speeds may be greatly increased and for the machining of such metals as aluminum, bronze alloys, cast iron, and babbit, it offers wide possibilities of time and money saving and is likely to cut down production costs substantially.

Lightning Protection
from the Operating Company's Point of View

BY E. HANSSON[1]

Associate, A. I. E. E.

Synopsis.—*This paper relates how one operating company has endeavored to protect its lines and transformers from lightning by means of additional insulation, ground wires, and various types of lightning arresters, and reports the results obtained. While some improvement was apparent from each scheme, the most effective protection seems to be derived from ample insulation.*

DURING the last four or five years, a number of articles on lightning have appeared in technical literature, most of them concerned with the nature of the phenomena and the apparatus developed for its study, but very little has been said with regard the efforts of the operating man to protect his lines and equipment from lightning. This article will endeavor to relate what has been done by one operating company during its 20 years of experience.

The Pennsylvania Water & Power Company started operation in 1910 with one double-circuit 66-kv. steel tower line connecting the hydro plant at Holtwood, Pa. with Baltimore City. The conductors were arranged in a vertical plane with 7-ft. spacing. Originally, the line was insulated with 10-in. suspension insulators with five and six units per string. The units were of the Ohio Brass Company "A" type, spaced 5⅝ in. from center to center. One ⅜-in. steel ground wire was strung at the apex of the 416 towers. (Fig. 1).

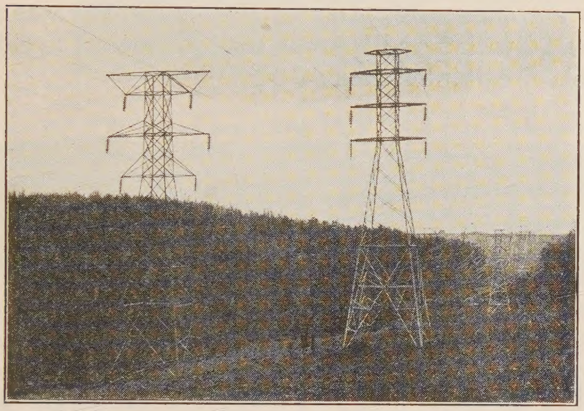

FIG. 1—CROSS-SECTION OF HOLTWOOD-BALTIMORE TRANSMISSION LINES

Left No. 56—Right No. 12

The first year's lightning season passed us leaving a record of 23 total interruptions and 10 voltage disturbances. Something had to be done at once and a wide awake salesman entering the office at the psychological moment sold three sets of lightning arresters which were duly installed at one-quarter points along the line. The arresters, which were of the electrolytic type, required daily attention and as their visible effect on operation was zero, they were removed after a short trial.

A detailed study of the location of the disturbances during 1911 revealed that by far the largest number of flashovers were located between towers 57 and 84, and towers 387 and 403. The insulation on these two sections was therefore increased by two units per string. The 1912 record showed only one flashover in this section as against 22 in the year previous. On the strength of this showing, all of No. 1 circuit was reinsulated prior to the lightning season in 1913. Checking up on the 1913 record we found that the more heavily insulated circuit had scored 27 flashovers as against 20 on No. 2 circuit which had less insulation. At first sight it appeared that increased insulation made matters worse, but a close inspection of the line brought out the fact that the spill-overs had taken place from cable or clamp to the crossarm below, rather than across the insulator string. In other words, the relation between the length of insulator and the air gap was such that the gap was appreciably weaker and therefore broke down first. (Fig. 2.) Three-wire short circuits were practically eliminated with the result that there was less loss of synchronous load. So far, we were satisfied that we were on the right track. The crossarm spacing, however, proved

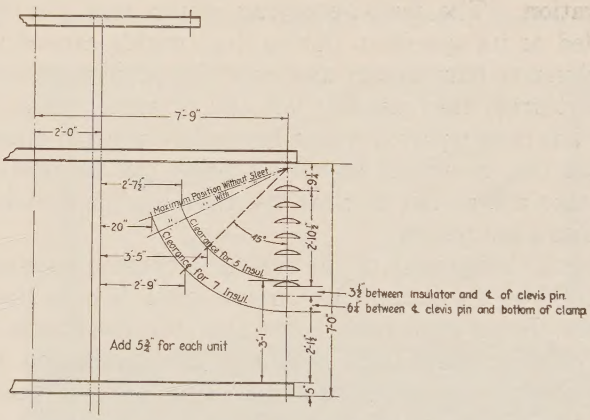

FIG. 2—CLEARANCES FOR FIVE- AND SEVEN-INSULATOR UNITS On Baltimore Line No. 12

1. Transmission Engineer, Pennsylvania Water and Power Co., Baltimore, Md.

Presented at the Middle Eastern District Meeting No. 2, of the A. I. E. E., Philadelphia, Pa., October 13-15, 1930. Printed complete herein.

a physical limitation to the length of insulator string that could be used and a compromise was made by adding one unit per suspension string and two units per dead end string on No. 2 circuit.

Early in 1912 Mr. Nicholson of the Niagara-Lockport Power Company introduced a scheme for extinguishing an arc on the transmission line without loss of load. The device consisted of a set of relays (both current and electrostatic) and switches, operated by the current in the short circuit or by the loss of voltage in case of a ground. The function of the switches was to throw a fuse across the line or between phase and ground, as the case required, short-circuiting and extinguishing the arc. After the arc went out, the fuse blew. A mechanical device would replace automatically a blown fuse so as to have the apparatus ready for the next flashover.

Simultaneously, a field-destroying relay developed by Mr. Ricketts of the Consolidated Gas Electric Light & Power Co. was introduced at Holtwood. To a degree, both of these devices were successful but the arc extinguisher required an unreasonable amount of maintenance and also had a habit of operating on low-voltage troubles when its operation only complicated matters. It was discontinued therefore after the 1917 season when a fourth Baltimore circuit was put in operation. The field-destroying device was also discarded as its operation during line trouble caused the machines to hunt to such an extent that after the trouble was cleared, they usually fell out of step. This device has been replaced with a manually-operated master switch, by means of which all fields can be opened. If other means fail to clear the trouble, this switch is used as a last resort.

Due to the growth of the system it became necessary to build an additional two-circuit tower line to Baltimore. Experience had shown that the clearances on the old line were insufficient and the spacing on the new towers was therefore increased to 9 ft. Proceeding on the theory advocated at this time that if one ground wire was good two must be better, the line was equipped with two ground wires. After the epidemic of insulator troubles during 1912 and 1913, the manufacturers began to make considerable improvements in insulator design and were particularly anxious to guard against punctures. Consequently, they advocated the use of arcing horns. In the fall of 1914 the new line was put into operation with one circuit; the second circuit was added in 1917, completing our present four circuits to Baltimore.

Comparing the records from 1918 to 1922, inclusive, when both lines operated with two circuits each, we find that the old line with smaller clearances, old type insulators, and only a single ground wire had a total of 57 flashovers, while the newer line with all its improvements boasted of 73. So far as could be seen, the improvements had not accomplished a thing except that the addition of the two circuits had brought the total flashovers down from 11.6 to 6.5 per circuit year.

In the meantime, various agencies had collected a great amount of data as to the effectiveness of ground wires and arresters. This information was highly contradictory and full of personal opinions; the majority, however, seemed to agree that ground wires were not only of no value but were the cause of much trouble, and that arresters, while useful on low voltage, could not justify their cost on higher voltages. Our own experience pointed the same way and seemed to be particularly conclusive, as our comparison had been made on parallel lines operating under identical conditions. Therefore, when the company's service was extended to York and Coatesville, the lines were built without ground wires and the arresters at the stations omitted. But provision was made for adding a ground wire later. To make them suitable for 110-kv. operation, the crossarm spacing on these lines was increased to 10 ft. A year later, in 1924, a line of identical design was built to Lancaster and in order to furnish a direct comparison on our own system, this line was equipped with a ground wire. One circuit on this line was also insulated with 9 and 10 units with the idea of avoiding double-circuit interruptions.

Fig. 3—Corona Points on 2/0 Copper Wire

The 1924 season was very mild in regards to lightning and we had few interruptions, but in 1925 we were again confronted with the same old problem of protecting our customers' service. Sometime previous Doctor Whitehead had approached us with a scheme of utilizing corona for reducing excess potential on the transmission lines. This scheme had originated in Germany where an investigator discharged a condenser, first on a smooth wire and again on a section of barbed fence wire, measuring the voltage to ground by means of a sphere-gap placed at the far end of the line. His test proved that the corona formed on the barbs caused a considerable reduction of potential even on his short experimental line. Doctor Whitehead assisted in determining the proper size and spacing of the barbs for our particular size wire and one mile of circuit was fitted out with corona points (Fig. 3). The klydonograph which had just been developed by Mr. Peters furnished a means of measuring instantaneous potentials and through the courtesy of the Westinghouse Electric & Manufacturing Co., loan was obtained of enough instruments to equip not only the circuit fitted with corona points but also its mate. The following year this experiment was extended to another circuit and the distance of corona point installation increased

to two miles. A large number of interesting pictures on the klydonograph was secured indicating surges varying from one and one-half to seven times normal voltage, but nothing in any way indicated that the corona points were effective. To personal knowledge, no corona on these points was ever observed by the eye but it could be distinctly heard, particularly in warm weather; and if the entire line had been equipped, it probably would have helped to attenuate the surges, but not sufficiently to justify the expense. The points were later removed as they caused a certain amount of trouble to nearby radio fans.

Fig. 4—Westinghouse Type Line Arresters Mounted on Dead-End Tower

During all these years a detailed record was kept of the performance of our lines but they were apparently contradictory and things seemed to be at a standstill. In the meantime the manufactures had been busy and had developed certain equipment, such as lightning generators, cathode ray oscillographs, osisos and surge recorders for studying the problem. Among other things, they had proved that an insulator when subjected to an impulse with a steep wave front does not always behave the same way as when subjected to a sustained 60-cycle voltage. The impulse flashover, for example, is not affected by the spacing of the units, but is a linear function of the length of the string. The protective value of ground wire was established by laboratory experiments and much of the guess work in its application eliminated.

Applying this new knowledge to our own records, we found that some of our deductions were wrong and we were able to clear up some of the apparent contradictions. For example, we had previously been unable to explain why No. 5 and No. 6 Baltimore circuits protected by two ground wires had a worse lightning record than No. 1 and No. 2, which were protected only by a single ground wire. We began to suspect that this was due to the arcing horns on No. 5 and No. 6 circuits, which had the effect of reducing the impulse flashover to the extent of nearly two units. In order to test our theory, in July 1926 we removed the horns from the Coatesville circuit No. 14 leaving the horns on the No. 13 circuit, which was on the same steel tower. Comparing one full season's record, before and after the removal of the horns, we found that No. 14 circuit had three more flashovers than No. 13 before the horns were removed, and eight less than No. 13 after removal of the horns. This proved to our satisfaction that the apparent lack of protection from the additional ground wire on circuits Nos. 5 and 6 was due to the arcing horns, and we decided to try a ground wire on the Coatesville line. This installation was completed in May of 1928. That summer we had 14 circuit interruptions on this line as compared with 30 the year before. As mentioned before, the Lancaster line had been built with extra insulation on one circuit and the performance of this highly insulated circuit had been much better than that of its mate. It was logical to conclude that if one of the Coatesville circuits was more heavily insulated than the other, the performance would be improved. Extra insulation was added in April 1929, and the following season, which was an exceptionally heavy lightning season, there were 16 single and 12 double circuit operations. However, No. 14 circuit, had 12 flashovers less than No. 13. A comparison of the 1928 and 1929 records of these circuits illustrates the difficulty of making comparisons of line performances over short periods. By comparison of three years' operation of the same line without ground wires with the two years' operation after the ground wire had been added, it was found that the average number of interruptions per year reduced from 24 to 17½.

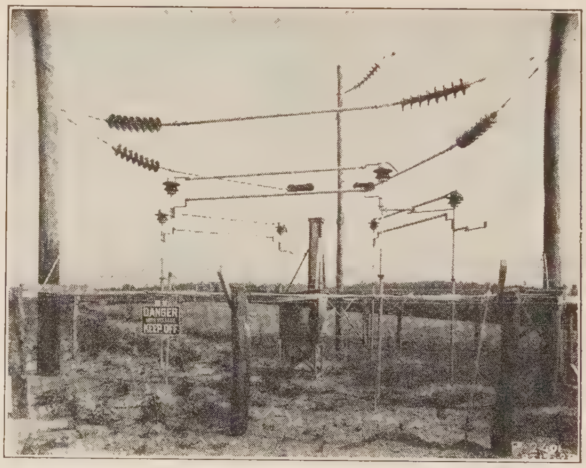

Fig. 5—Arrangement of Klydonograph on the Holtwood-York Circuits

Early last spring, the Westinghouse Manufacturing Company approached us with a proposition of trying out on one of our circuits a new type line arrester which they had developed. The arrester is essentially an auto valve arrester of very compact design so that it can be mounted on the tower crossarms. Twenty-two sets of these arresters were installed on York No. 11 circuit. (Fig. 4.) In order to check results, klydonographs were installed on both circuits. (Fig. 5.) The

arresters did not seem to help, as after installation, No. 11 circuit had eleven, and No. 12 circuit had twelve interruptions. Unfortunately, however, the installation was delayed until June 30th so that we missed the violent storms in the early part of June last year. In comparing the records of the two circuits, there should be taken into account the fact that in the previous year, the horns had been removed and an extra unit added to the insulation on the greater part of No. 12 circuit. The arresters were on the circuit of lower insulation. Furthermore, no flashover was found within two spans of any arrester installation. This looked so hopeful to the Westinghouse engineers that they offered to supply more arresters to be installed this year, so that the maximum distance between any two arresters will be not more than four spans.

The klydonograph records were disappointing as the films flashed over during each surge in spite of a potentiometer ratio of 30 to 1, indicating a voltage of from 6 to 16 times normal. We do not know if such voltages actually existed, or if the ratio of the potentiometer was upset by corona, or whether the leads were insufficiently shielded. The experts seem to lean toward the opinion that the surges actually reached the values indicated.

The manufacturers have always contended that by over-insulating our lines and substations, we were taking long chances on our transformers and we soon did run into trouble with the bushings on the 60-cycle transformers. These bushings were rated at 73-kv. and were of the compound-filled type. During 1924 we had six bushing flashovers with eight transformers in service. The matter was taken up with the manufacturers and they recommended the tapering of the line insulation at the stations and the installation of arresters. Compromise was finally made by installing arresters on both ends of circuit No. 16, by purchasing 88-kv. bushings on the new transformers for both ends of the circuit, and by replacing the 73-kv. bushings on the Holtwood end on Nos. 13 and 14 circuits with 88-kv. oil filled type. This was done before the 1925 lightning season. That summer, there were 42 flashovers, 32 of which occurred on the York circuit transformers which still had the 73-kv. bushings, five on the Coatesville transformers before the bushings were changed, and three after the change had been made. Two occurred on the Holtwood No. 15 transformer which also had old type bushings and no arresters. The oil filled bushings not only proved their ability better to withstand the surges, but when they did flash, the damage was insignificant. Station arresters are now installed on all circuits except No. 12 and Holtwood end of No. 13, and all transformers except No. 15 at Holtwood have been equipped with oil filled bushings. Last year we experienced no flashovers on 88-kv. bushings protected by arresters, but on those unprotected by arresters, there were eight flashovers. As a result of this experience we are completing arrester installations on all circuits.

In the fall of 1925, the insulation on two dead ends at each end of circuits Nos. 11 and 12 and the Holtwood end of circuits Nos. 13 and 14 was reduced. The result for the York circuits was 17 flashovers on the reduced insulators,—two of them simultaneous with the bushing flashovers—and three bushing flashovers without any simultaneous flashovers on the weakened insulators. The parallel record for circuits No. 13 and 14 was eight bushing flashovers without any flashing of the weakened insulators.

A complete breakdown of one of the weakened strings at the substation end of the York line caused us to replace these relief insulators with fused grading rings. At first we installed five sets at each end of No. 12 circuit with a gap setting of 32 in. (Fig. 6). This setting proved to be too wide and was later reduced to 22 in. The following year we added 10 more sets at

Fig. 6—Fused Grading Rings Mounted on Dead-End Tower

each end. Since the fuses were installed there have been three bushing flashovers on this circuit, and in one case the fuses nearest the bushing (about 40 ft. away) did not operate.

A device which so far has had a good record is a home-made arrester consisting of a gap made of two parallel plates with their edges bent back so that the flashover always takes place between the parallel faces. The setting of this gap is five inches and in series with the gap is an expulsion fuse. An automatic mechanical device replaces the fuse as soon as it is blown. Two of these arresters, one at each end of circuit No. 11, have been in service since July 1928, and we have had no bushing flashover on that circuit during this time; yet as many as six fuses have been blown in one storm.

On our 60-cycle system there were three transformer breakdowns all of which originated in the tap changers of delta-connected three-phase units. These we believe were due partly to lightning surges and partly to a weak design. Two of these transformers were provided with arrester protection.

As a result we have installed on all ungrounded trans-

formers, tap changers of a higher voltage rating. The protective value of the 60-cycle arresters also have been increased by cutting out five per cent of the cells. To date, no further transformer failures have occured. The manufacturer still insists, however, that our transformer windings are subject (although to a lesser extent) to excessive voltages due to the heavy line and bushing insulation.

So many factors enter into the performance of a transmission line that it is extremely difficult to make comparisons between two different lines. Performance is affected by the number of storms, the violence and duration of the storms, by soil conditions (which govern the resistance of the tower ground), by the configuration of the country the line passes through, and by location of nearby objects. In order to avoid these difficulties, we have based our conclusions, so far as possible, on the performance of parallel circuits where conditions necessarily would be very much alike.

Increasing the insulation was found to be the most effective way of improving a line although there is of course an economical limit to the amount of insulation that can be put on a line, as the longer insulator string requires longer crossarms and wider spacing, and therefore increases the cost of the towers.

A ground wire is helpful, but the benefit is very hard to evaluate as its effectiveness depends on so many factors. One of the principal factors is tower resistance to ground. Under many conditions it is extremely hard to provide low ground resistance.

Lightning arresters have improved service by reducing the number of bushing flashovers. However, for an arrester to be wholly effective, there must be ample margin between the transformer insulation and the voltage maintained across the arrester during discharge.

Abridgment of

The Communication System of The Southern California Edison Company, Ltd.

BY ROY B. ASHBROOK[1] and FRED B. DOOLITTLE[2]

Member, A. I. E. E. Associate, A. I. E. E.

Synopsis.—*This paper gives a general description of the Southern California Edison Company's communication system which not only meets the requirements of load dispatching but also serves to bring about close cooperation between the outlying district forces and their directing heads at division headquarters and in the general office. The detail of development and construction by the company of the "serjdetour" arrester is made public for the first time. This piece of equipment has made possible a protective system which not only prevents damage to valuable communication equipment in stations for the extreme case of actual contact between telephone lines and power lines but also preserves continuity of communication service after power system disturbances which create surges of considerable magnitude on inductively exposed telephone lines have taken place. A brief outline is presented of the standardized assemblies of telephone equipment into units which are adaptable to wide variations in requirements by the use of different combinations and quantities of standard units. The communication building, the center of a telephone system, is described, as is also the method of handling traffic through this point. A brief description of the equipment for making initial tests on new lines and maintenance of existing facilities is given.*

* * * * *

Introduction. In general, the communication system of a power company is not given the consideration it deserves; in fact, its existence is usually only through necessity. In most cases the lines are built jointly with power transmission lines where special coordination and protective measures are required to provide high-grade communication service.

The extent of the communication system is such that it renders complete telephone service to all departments within the company, serving an area of 55,000 sq. mi. through three 100-unit private automatic exchanges, a modern three-position toll-board and three outlying exchange centers. It involves 6000 circuit miles of toll line, 400 circuit miles of cable and 1400 telephones, representing a capital investment of over two and a half million dollars in communication plant. (See Fig. 1.)

Protection. The need for immediate use of the communication facilities of a power company is greatest following an abnormal occurrence causing the automatic operation of oil circuit breakers in the transmission network. The status of wire telephone facilities as to serviceability immediately after power system trouble depends on the design and proper operation of the telephone protective equipment. The chief requirements of protective apparatus for power system telephone lines are, first, that this equipment shall not be blown to pieces by discharge resulting from direct contact between a telephone line and a power line; and second, that it shall be capable of carrying the currents occasioned by induced surges arising from power system troubles without becoming internally short-circuited.

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As these requirements are not met by any commercially available protective gaps, it was necessary to develop this device which has been named the "serjdetour."

The serjdetour is capable of sustaining the discharge occasioned by contact between a telephone line and a power line with no damage other than the welding together of the electrodes. When this occurs, it is only necessary to loosen four screws, remove the pitted electrodes and substitute new ones. The device is then again ready for service. The pitted electrodes can readily be re-surfaced in the shop.

While direct contacts between telephone and power

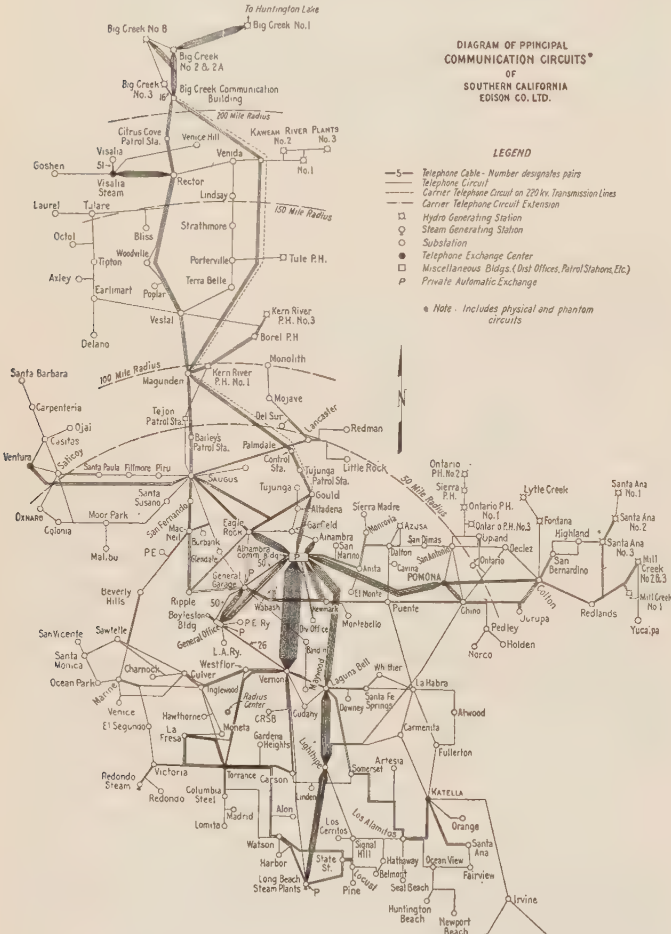

FIG. 1—MAP OF THE IMPORTANT COMMUNICATION CIRCUITS

lines occur occasionally, the great majority of disturbances consists simply of induced voltages to ground or between wires, due to exposure to power circuits under fault conditions. The discharge currents resulting from such induced voltages are much more moderate in value than those resulting from direct crosses, and the serjdetour is capable of handling these without becoming internally short-circuited. This is an extremely valuable attribute, as it means continuity of communication service despite power system troubles.

The serjdetour in its most common form consists of a group of three gaps designed to be connected from each wire to ground and between wires, respectively. Each gap consists of a pair of cylindrical copper electrodes clamped in three-inch steel cubes. (See Fig. 2.) The faces of these cubes are machined, and are held parallel by a Pyrex ring separator. This brings the faces of the electrodes into perfect parallelism, and the spacing between them is readily adjustable. The electrodes are tipped with pure rolled silver a quarter of an inch thick, so that it is the silver which actually forms the arcing surfaces. The silver faces

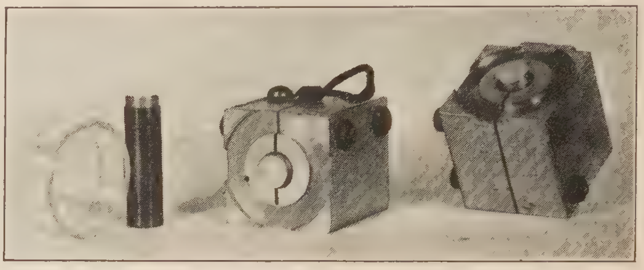

FIG. 2—THE COMPONENT PARTS OF A SERJDETOUR GAP

Showing the Pyrex spacing ring, the silver tipped copper electrode, and the electrode mounted in its heat, absorbing block

are machined with the greatest care, to be perfectly flat except for a slight beveling at the edges. By the use of rouge, they are given a mirror-like polish. The success of the arrester action depends on the perfect parallelism of the faces and the smoothness of their surfaces. When these conditions are fulfilled, the arc spreads uniformly over the entire surface of each electrode face, and so has no tendency to concentrate at one place and build up a projection. It is also essential that the silver

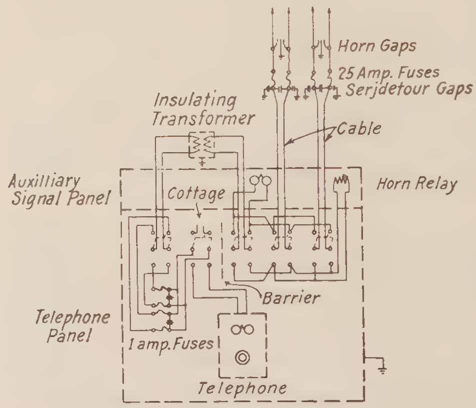

FIG. 3—TYPICAL TELEPHONE CIRCUIT FOR A SUBSTATION AT AN INTERMEDIATE POINT ON AN IMPORTANT DISPATCHING LINE

faces be backed by the large copper electrodes and the massive metal blocks, as this insures that the heat will be conducted away from the surface and absorbed in the blocks, thus avoiding an undue melting of the silver.

The serjdetour is not in itself a complete protective measure, but is the foundation unit upon which the protection system is built. The duty which this unit must perform is illustrated by Fig. 3, showing a typical telephone circuit for a substation at an intermediate point on an important dispatching line. For

convenience in sectionalizing for test from a central wire chief's office, the line is looped through the switching panel in the station instead of merely being tapped. Continuity of service is a prime requisite; therefore no small fuses or protective gaps are inserted between the terminal pole and the switching panel. The serjdetour and its associated 25-ampere, 25,000-volt arc-quenching fuses, are mounted on the terminal pole. The telephone instrument is insulated for potential from line to ground of 25,000 volts by the insulating transformer installed between the line switching panel and the telephone panel. It is also protected from destructive between-wire voltage by duplicate sets of one-ampere fuses, and gaps, either set being selected by the fuse changing switch on the telephone panel.

Since the switches on the line switching panel are at line potential, protection of the operator requires that live parts be covered and that operation of the switches be through a handle of ample insulating value. The switches are double-pole, double-throw, key type, and are operated by a long Bakelite handle extending through the metal cover enclosing the entire grounded metal panel upon which they are mounted. The silver contacts have a wiping action to insure low-resistance connections necessary to maintain balance, which is of great importance in lines exposed to inductive interference.

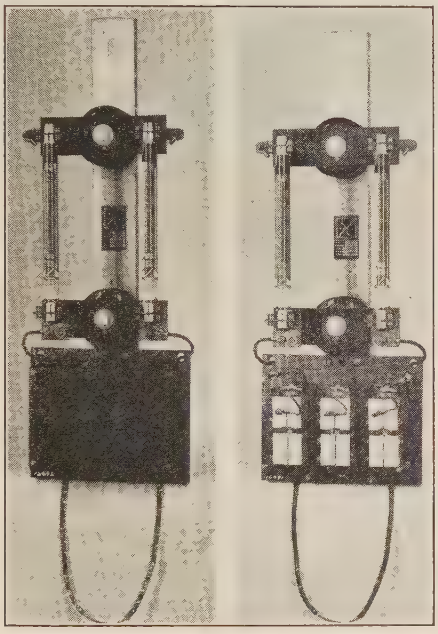

Fig. 5—Southern California Edison Company's Serjdetour Protective Unit

For use on exposed telephone lines

The equipment on the line switching panel and the rubber-insulated lead-covered lead-in cable will withstand a potential of 1700 volts to ground while the bells, relays, and insulating transformers have been tested and found capable of withstanding 600 volts between wires. Thus it is required that the serjdetour positively limit the voltage to ground to 1700 volts and the between-wire voltage to 600 volts. To meet these requirements, the serjdetour combination shown in Fig. 5 was assembled. This consists of two gaps set for 1700 volts and one gap set for 600 volts. The unit is combined with the 25-ampere, 25,000-volt arc-quenching fuses to form a protector unit for installations such as that just described.

In cases o' contact between a telephone line and a power line, the 25-ampere, 25,000-volt fuses on the line side of the serjdetour have opened and an arc has started at the horn-gap arrester located on an adjacent pole, thus eliminating any tendency for flashovers on the terminal pole and protecting valuable inside telephone equipment from damage. In addition, the serjdetour has protected telephone equipment in a large number of inductive disturbances without any interruption of communication service.

Carrier Current. On the 220,000-volt backbone of the system, every possible step must be taken to preserve continuity of communication. Owing to the mountainous nature of the country which the lines traverse, there is always the possibility of the telephone lines being damaged by sleet storms, brush fires, etc.; therefore it was considered advisable to install a carrier-current telephone system. This extends from the Big Creek No. 3 hydro plant by way of the 220,000-volt Big Creek and Vincent transmission lines to Gould switching station near Los Angeles, with a wire extension to the supervisory dispatcher's office. An intermediate carrier-current telephone station is provided at the Magunden switching center.

Station Equipment. Four general types of station equipment fulfil the requirements on the Southern California Edison system. The choice between types is determined by the amount of telephone traffic to be handled at each location.

The first and simplest type of equipment consists of a telephone enclosed in a weatherproofed wooden box arranged for attachment to a pole. The second type of installation consists of a steel panel on which is mounted a telephone and five enclosed dead-front switches, and which may be extended to provide for terminating or looping more than two lines by the addition of one or more four-line panels. (For example see Fig. 7.)

The fourth and most elaborate standardized installation makes use of a desk type switchboard having a slanting key shelf, accommodating 27 lines, and providing four busses for switching and two for talking. Each line position is equipped with three standard telephone keys, a white lamp which flashes the code rings, and a red lamp which remains lighted for ten seconds after the termination of a ring, to assist the operator in locating the line when he has heard his code call but did not see the white light. Bells mounted in

the back of the desk give audible signals on the magneto lines, and the usual night alarm buzzers are used on the common battery lines. Each talking bus is equipped with an operator's telephone connection which includes an acoustic shock suppressor in the receiver circuit. The acoustic shock suppressor developed by the company consists of a vacuum tube amplifier circuit using low plate voltage so that the output of the amplifier is limited by saturation of plate current below such value as would produce acoustic shock on reaching the receiver.

This desk known as type *A*, (Fig. 8), provides an

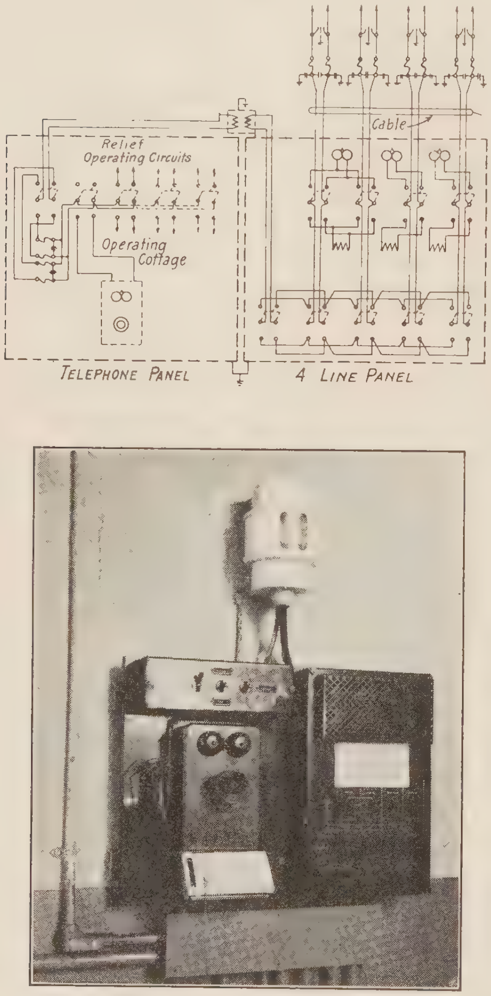

Fig. 7—Typical Installation of a Four-Line Panel and Circuit Diagram

Showing one line looped through and two lines terminating

annunciator panel in addition to the telephone panel. On this panel are mounted lamps which give indications of power switching operations, transformer temperatures, etc. Both panels are built in and are completely wired to terminals in the back of the desk.

From the terminals on the desk, all the circuits are carried in cable to a cross-connecting box located in the rear of the unit type equipment panels used as auxiliary with this desk.

Exchange Centers. The communication facilities required for other than dispatching the immediate operation of the power system are provided in a manner similar to that of commercial toll service. The term "toll" as used here applies to service between different localities that may be handled on a delay basis. Fig. 12 shows the layout of circuits serving the eastern

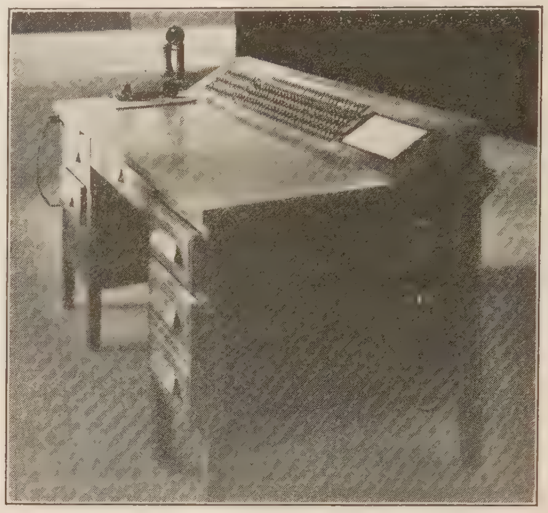

Fig. 8—Type "A" Telephone Desk Showing Keys and Lamp Signal Arrangement

The annunciator panel to the left of the key shelf is equipped with 30 positions, with space to the right for additional positions when required

division, which is typical of the requirements of any one of the six operating divisions of the system.

Communication Building. The heart of the communication system of the Southern California Edison Company is the communication building located in Alhambra.

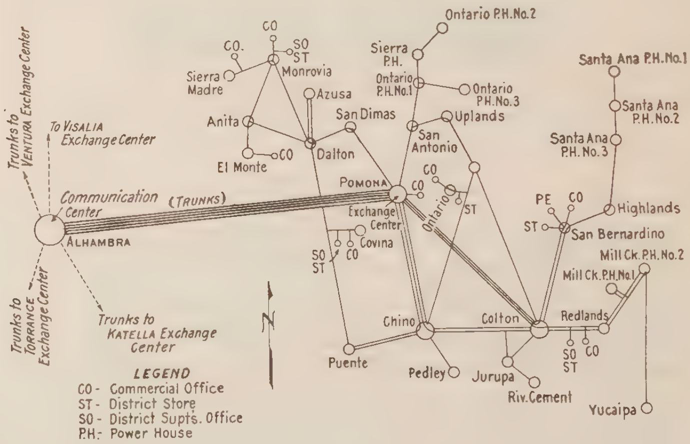

Fig. 12—Layout of Circuits Serving the Eastern Division

The telephone circuits terminating at the communication building are protected and carried in underground cables to the equipment panels just as in any large substation installation. From these panels, they are distributed to the dispatchers' desks, the toll board, and the wire chief's board. Many of the long lines are party lines and ringing on them is so frequent that it would be confusing to the dispatchers and toll

operators if they received all the signals. To avoid such a possibility, a selective device operated by the ringing current and consisting of relays and a rotary line switch discriminates between the code rings and brings the line lamp in only on the particular board desired. The result is that in so far as the dispatchers and operators are concerned, the lines do not appear as party lines, their lamps lighting only when they are wanted and remaining on until they are answered.

Three 25-line key-operated desk switchboards provide a means of establishing direct connections from the supervisory dispatchers to the switching centers. These desks are similar to those described for the largest substations but have an additional feature which is a toll line selector. By dialing the circuit number on this selector, all of the lines terminating at the communication building are available to the dispatchers. In effect, each dispatcher has a 100-line switchboard within a very small space.

The three-position toll switchboard provides a connecting link from the intercommunicating systems serving the general office, general garage, and Alhambra properties, to the toll lines.

Line Testing and Results. When a new telephone line is constructed, it is tested in its entirety and in sections before it is accepted for operation. Any changes or corrections for improvement are made before it is put in service. A folder showing the route of the line, pole numbers, distance between poles, type of construction, size of wire and transposition scheme, together with a report of the initial tests, is made up at this time and filed where it is available to the wire chief, thus providing records for reference in maintaining lines up to standard.

Conclusions. Several years' experience with a constantly improving communication system has demonstrated that good telephone communication promotes close cooperation between departments of the company to the end that better service may be rendered to consumers.

Abridgment of

Voltage Oscillations in Armature Windings Under Lightning Impulses—I

E. W. BOEHNE*

Associate, A. I. E. E.

Synopsis.—*Experience has shown that rotating machinery connected directly to overhead lines is more vulnerable to surges than many other types of apparatus. This fact, together with a desire on the part of some to connect important units to the line in this manner, has necessitated a study of the protection problem. Such a study is here described, showing oscillograms taken when steep voltage surges were applied to machine windings measuring internal voltages to ground which are 200 per cent of the voltage allowed by the terminal lightning arrester. A simple traveling wave analysis of these oscillations is developed, which has successfully explained the pecularities of over 400 oscillograms taken under various terminal conditions. Practical methods of eliminating the oscillations with neutral impedance are outlined in the light of the theory developed, and oscillographic evidence supporting their reliability is given. A generalized theory of neutral protection is proposed. The importance of wave-front, surge impedance of incoming line, arrester resistance, and other factors is discussed. Methods for protection of the turn insulation and the insulation to ground of such machines are suggested, showing that the lightning arrester limits only the potential of waves entering the machine and cannot control oscillations which may take place within the machine. The advantages of thyrite as a neutral resistor are pointed out in connection with the short-circuit protection, telephone interference, and lightning protection problems of such machines. In Appendix A, the test circuits and methods used in the laboratory are discussed in relation to actual field conditions.*

Object

The object of this paper is threefold:

1. To explain the internal oscillations in machine windings when subjected to steep wave fronts. It is shown by a cathode ray oscillograph study, followed by theoretical considerations, that the highly oscillatory internal voltages rising in some instances to 200 per cent of the terminal voltage are primarily due to successive reflections of a traveling wave in the machine winding.

2. To show that the oscillations may be eliminated by connecting between the neutral of the machine and ground, a resistance equal to the characteristic surge impedance of the machine winding.

3. To present an analysis of the protection of the insulation between turns of machine windings and to ground. It is shown that the voltage stress between turns may be reduced by shielding, or by placing a capacitor in parallel with an arrester unit.

Oscillograph Investigation

A cathode ray oscillograph investigation forms the foundation of the study and resulting theory presented in this paper. Three machines ranging from a small 2200-volt induction motor to a 24,000-volt synchronous condenser were tested, and all were found to perform

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in a similar manner under artificial lightning surges. The lightning generator used for the tests was designed to represent electrically an equivalent transmission line of definite surge impedance delivering a given wave. It is felt that this phase of the study is of considerable importance; a detailed analysis and discussion is given in an Appendix A, where it is proved that the test circuit used is an accurate representation of transmission line traveling wave conditions.

Oscillogram Characteristics

All of the oscillograms shown in the paper are of voltage to ground with respect to time. Each

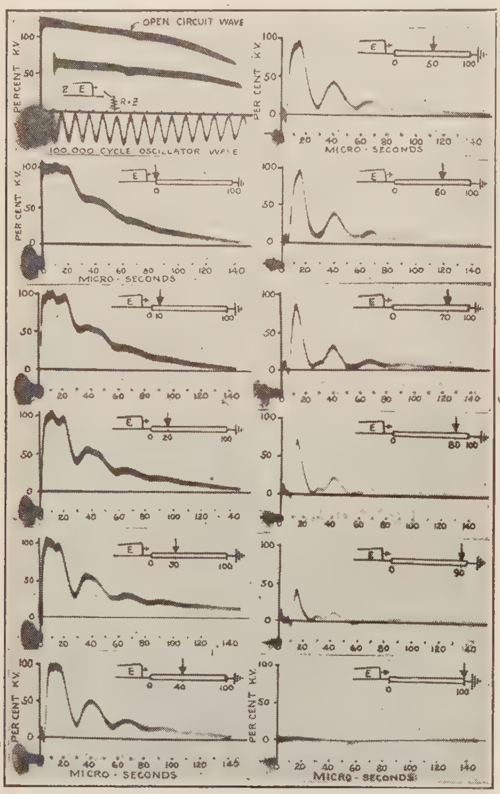

Fig. 1—Tests on 6600-Volt Winding, Neutral Grounded

is titled with a figure, the key to which is as follows:

A single phase of a machine winding is represented by the rectangle shown in each diagram. In all cases the traveling wave approaches from the left. The point at which the voltage is measured is indicated by an arrow on the winding with the corresponding percentage from line terminal indicated below the arrow. The condition of the opposite end of the winding is important and is given in the usual notation. Hence, Fig. 1 is an oscillographic record of what takes place in the winding of a 6600-volt machine when a steep wave is applied to its line terminal and the opposite end grounded.

In all cases the voltage is scaled in per cent of the wave which enters the machine winding, this being defined as the applied wave. It will be seen later that this is equivalent to the arrester voltage. The abscissa is time, the reference point in each case being taken at the moment the wave reaches the line terminal of the machine. Similarly, Fig. 2 is the record when the neutral of the same winding is open, the same wave being applied as in Fig. 1. In these tests, the rotor was removed and only a single phase of the machine was tested.

A study of these oscillograms will be made here by listing some of the outstanding relations which are apparent:

1. The maximum voltage with the neutral open is twice that with the neutral grounded.

2. The frequency of the oscillations with the neutral grounded is twice that with the neutral open.

3. The time delay of any appreciable voltage rise increases in proportion to the distance from the line terminal at which the voltage is measured.

4. This time delay is the same with the neutral open or grounded.

5. The voltages oscillations measured at various points in the winding with either the neutral open or grounded are substantially "in-phase."

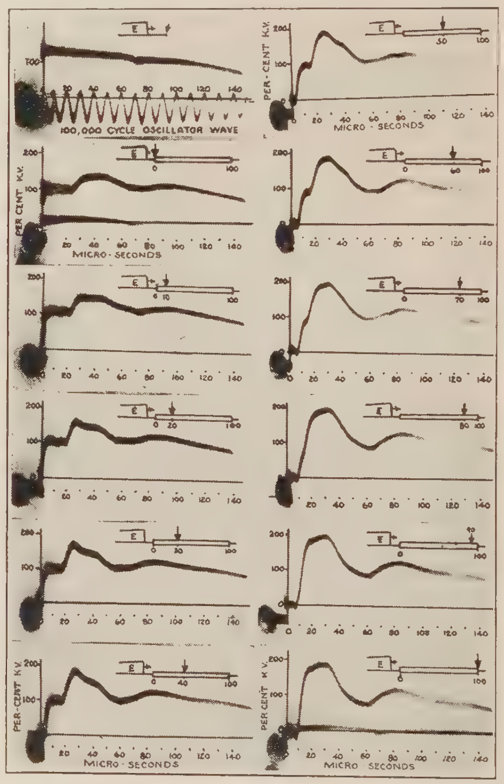

Fig. 2—Tests on 6600-Volt Winding, Neutral Open

6. A certain flat top characteristic is evident in many of the oscillograms, it being predominant near the neutral of the open neutral winding and near the line terminal of the grounded-neutral winding.

7. All records are distinctly unidirectional.

The lightning generator for these tests was designed to represent a transmission line of 250-ohm surge impedance delivering a very steep wave. (See Appendix A.) The criterion for such a line is that when a resistance equal to 250 ohms is placed across the open end, the terminal voltage will be half of the open-cir-

cuit wave. Such a relation is shown in the upper left hand corner of Fig. 1.

Explanation of Oscillograms

It will be shown that the voltage oscillations bear a marked similarity to those which would occur on a short length of transmission line when subjected to a similar transient force. Consider the simple case of a suddenly applied voltage to the line shown in Fig. 3.

The use of the equivalent transmission line of 250 ohms accounts for the minor peculiarities of these oscillograms, as shown by comparing with the calculated voltages for a few points in the winding as shown in Fig. 3. There is excellent agreement with the recorded voltages.

Making a study of Fig. 3, it is found that each of the seven characteristics which were tabulated in the study of the oscillograms of Figs. 1 and 2 is distinctly true in this case of a simple finite transmission line. These seven characteristics may be considered as criteria of traveling wave phenomena.

This analysis forms a basis for the theory that each

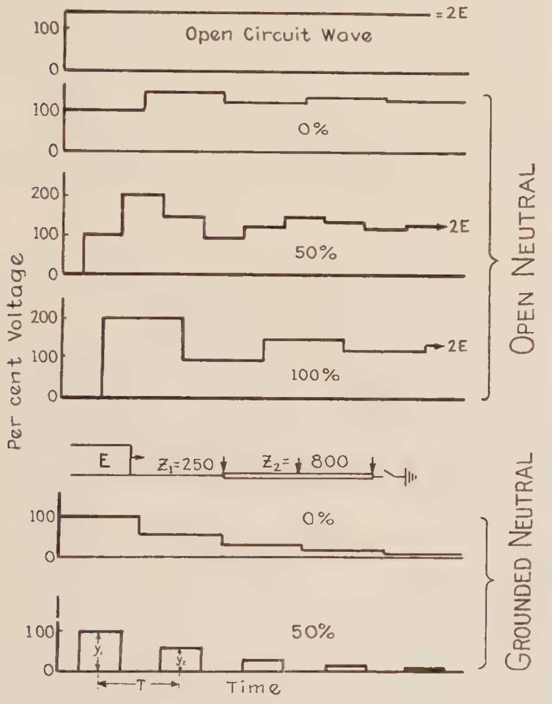

Fig. 3—Calculated Voltages in 6600-Volt Winding

phase of a generator winding functions as a finite transmission line to traveling surges.

Protection of Windings

In inductive windings there are two distinct insulations to protect; namely, the insulation to ground and the insulation between turns.

In practical cases the voltages to ground are a direct function of the maximum voltage allowed by the line terminal arrester. The arrester voltage is the applied wave to the machine. However, with an open neutral machine it has been shown that due to reflections of a steep wave at the neutral, double-arrester voltage occurs in the winding which may cause the insulation to fail. This can be reduced to arrester voltage by grounding the neutral, or by placing in the neutral-to-ground a resistance equal to, or less than, one-third of the surge impedance of a single winding.

The lightning arrester is essentially a device for the protection of the insulation to ground of inductive windings by limiting the maximum voltage of the wave entering the winding, while the neutral resistor is an agent for the protection of the same insulation by preventing positive reflections from taking place at an open neutral. It should be observed, however, that

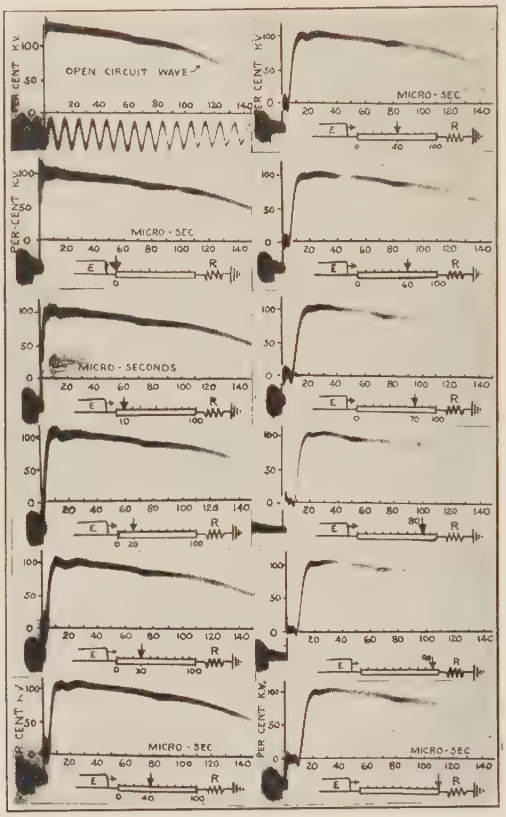

Fig. 4—Tests on 6600-Volt Winding with a Resistance Equal to the Surge Impedance in the Neutral to Ground

in the protection of the insulation to ground any resistance less than this value may be used.

Neglecting for the moment the induced voltages in the adjacent turns, the voltage between turns for any given machine is a function of the steepness of the applied wave. This follows on the assumption that as indicated on the oscillograms the wave requires a definite time to travel an integral length of the metallic circuit of the winding. Consider a steep wave entering the winding of Fig. 5 the wave traveling at a velocity v. When the tip of the wave arrives in the second turn, directly below the point of entering the winding, the voltage between turns will be e_1 volts, which will be smaller with slower fronts. The effect of the induced voltage is always in a direction to lower this maximum stress. As the wave travels through the winding, its

front becomes slower (see Fig. 4) and hence the maximum stress occurs on the end turns. In case of an open neutral, the steepness of the wave arriving at the neutral doubles when the positive reflection occurs.

Either a steep rise or a sudden drop in voltage may produce high stresses between turns. A steep drop in

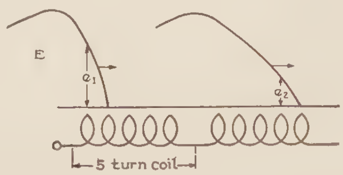

Fig. 5—Schematic Diagram of Wave Entering Generator Winding—Showing the Relation between Wave Front and Voltage between Turns

voltage may be caused by any sudden change of circuit such as an insulation flashover close to the substation. Special means must be employed to reduce these steep gradients.

One method is to use a single capacitor to ground in parallel with each lightning arrester. Such a capacitor may be considered as a protective unit for the insulation between turns of inductive windings. Moreover, in slowing up the wave-front of a steep surge the capacitor affords protection to the insulation to ground should it be necessary to operate with an open neutral. This is clearly shown in Fig. 6.

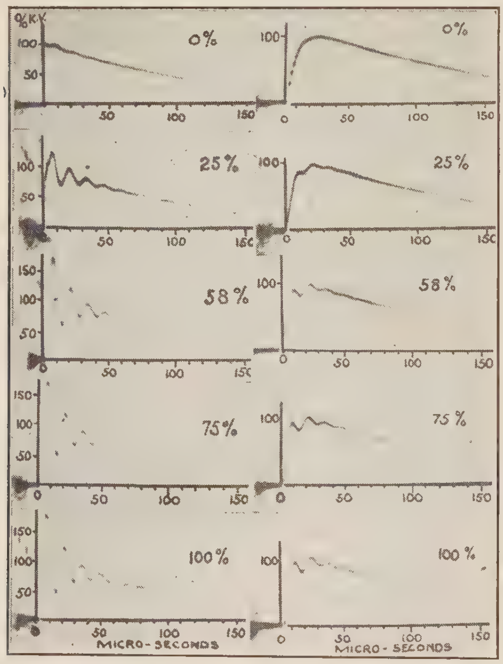

Fig. 6—Oscillograms Showing the Reduction in Oscillations with Slow Wave Fronts in a 2200-Volt Induction Motor

Machine voltage	Velocity of wave in winding (miles per second)	Surge impedance of winding (ohms)	Equivalent length of transmission line (miles)
V	v	Z_g	L
2,200	10,100	685	0.627
6,600	10,600	800	2.32
24,000	10,900	1000	4.65

Summary

An oscillographic study of the transient oscillations in machine windings has been presented revealing the following facts:

1. That machine windings subjected to transient surges function as finite transmission lines of several miles in length, obeying the natural laws of reflection and propagation of surges on an open line.

2. That due to reflections at open neutrals the maximum voltage to ground in a machine winding due to a unidirectional surge is double the maximum arrester voltage.

3. That the surge impedance of machine winding tested is in the neighborhood of from 600 to 1000 ohms while the velocity of propagation of the waves is in the neighborhood of 10,000 mi. per sec. in the slot portions.

The traveling wave analysis of the voltage oscillations has very simply accounted for the following secondary phenomena:

a. Relations between natural frequency and voltage magnitude in open, ground, and fractional windings.

b. Phase displacements and harmonic relations between various points in the winding.

c. Oscillation of voltage distribution curves as standing waves about the final voltage distribution.

d. Damping of the oscillations.

Three possible methods of reducing the disturbing oscillations in rotating machines were discussed. They are:

1. Reduction by slowing the front of the applied wave with a capacitor in parallel with the lightning arrester.

2. Preventing reflections at the neutral by grounding the neutral through the characteristic impedance of the machine windings.

3. Tapering the surge impedance of each phase from its normal value at the line terminal to a very small value at the grounded neutral.

In the light of the facts made known in this investigation, the following conclusions regarding protective equipment were reached:

a. That the lightning arrester is the most effective protective unit now available for the protection of machine windings. However, it only limits the magnitude of the wave which enters the machine winding, and cannot control the oscillations within the winding. It does not affect the front of the wave below arrester breakdown.

b. Neutral impedance when used can be made of thyrite and be an effective open neutral during normal operation and yet afford the necessary additional protection in case of a dangerous surge.

c. Capacitors in parallel with the lightning arrester afford adequate protection for the insulation between turns of machine windings. They also provide protection for the insulation to ground of machine windings by reducing internal oscillations in cases where the neutral is open. In this respect they may even be

designed to eliminate the oscillations in short, open, neutral windings.

d. The principles of shielding which have proved successful in protecting transformers[9] may also be applied to generator windings.

e. For the adequate protection of large units connected directly to the line, and with neutral open, some protection in addition to lightning arresters is necessary in order to insure that the internal voltages to ground will not exceed the arrester voltage and to adequately protect the insulation between turns.

ACKNOWLEDGMENT

The author wishes to acknowledge the helpful suggestions of Mr. P. L. Alger, under whose direction this investigation has been made possible.

Much credit is due also to Mr. C. M. Foust and his assistants Messrs. N. Rohats, H. R. Walker, and others whose help has made possible the oscillographic tests shown in this paper.

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Abridgment of

75-Kv. Submarine Cable for Deepwater Station

BY R. W. WILBRAHAM[1]

Member, A. I. E. E.

Synopsis.—*This paper describes the problems attending the laying of eight 75-kv. submarine cables across the Delaware River in the vicinity of Wilmington.*

To insure against injury, the cables were laid in a backfilled trench the depth of which was determined by experiments.

By terminating the cable on platforms just inside the pierhead lines it was possible to use a cable of 4050 ft. (maximum length possible for one of the accepted manufacturers to make) as compared with a river width of 5100 ft.

To avoid the excessive heating of that portion of the cable out of water at the cable platforms, the steel armor was replaced by one of non-magnetic material so designed as to avoid corrosion and electrolysis.

The problem of laying the limited lengths of cable in the trench with minimum deviation was satisfactorily met with specially developed methods.

The construction work was completed in five months, under winter conditions and with river traffic heavy.

* * * * *

THE location of the Deepwater Generating Station on the New Jersey side of the Delaware River, opposite Wilmington and four miles south of Pennsgrove, made it necessary to transmit a portion of the energy across the river to supply the Wilmington and Philadelphia districts.

An overhead wire crossing was proposed but refused by the United States Government as a potential hazard to aerial navigation. This made it necessary to consider a submarine cable, and a study of this problem developed a number of controlling factors, as follows:

1. It was desirable to use 66-kv. cable, but the longest piece obtainable was 3600 ft. as compared with the 5100-ft. width at the nearby narrowest part of the river.

2. Pierhead lines had been established on both sides of the river, thus extending riparian rights of land owners beyond the shore line, with consequent right to dredge to a 35-ft. depth or erect structures thereon.

3. All unused land at this narrowest part of the river on the Delaware side was owned by one person who refused to sell, and in Delaware a power company has not the right of eminent domain. This very greatly limited the possible location for a cable crossing.

4. This part of the river, below Philadelphia, League Island Navy Yard, Chester, and Wilmington, has considerable traffic. It is also a natural deep water basin in which ships anchor in fogs or storms, frequently dragging their anchors, as attested by interruptions in cables already laid on the bottom.

The solution of the right of way problem, and therefore the location of the crossing, was happily reached by the cooperation of the Reading Company which owned the riparian and upland rights on the Delaware side. Rights of way on this property were granted by the

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Presented at the Middle Eastern District Meeting No. 2, Philadelphia, Pa., October 13-15, 1930. Complete copy upon request.

Reading Company, and further inland for aerial lines by the Pennsylvania Railroad, (Fig. 1).

Cable

Analysis of the cable problem indicated the probability of successful operation of a circuit at 66,000 volts, which was desirable from the point of view of construction, operation, and economy.

The first and important step was to obtain an agreement by the manufacturers to increase the size of their factory equipment in order to make a cable of sufficient length. By terminating the cable on platforms just inside the pierhead lines, it was possible to use a cable of 4050 ft., which was the maximum length one of the accepted manufacturers could make.

The selected cable was rated at 75 kv. (between conductors), to be used on a nominal 66-kv., three-phase, 60-cycle system with solidly-grounded neutral. Eight single-conductor cables were so arranged as to make up two three-phase circuits with a spare conductor for each.

The cable is of the single-conductor type, paper-insulated, electrostatically-shielded, lead-covered and steel-armored. The conductor is of the standard stranded type (not hollow core), 750,000 cir. mils in area. The insulation is 54/64 in. thick, and over this is applied a perforated shielding tape. The lead is 5/32 in. thick, covered with two layers of asphalt-saturated jute and one layer of No. 4 galvanized steel wire armor, giving an over-all diameter of 3¾ in. and a weight of 21 lb. per ft.

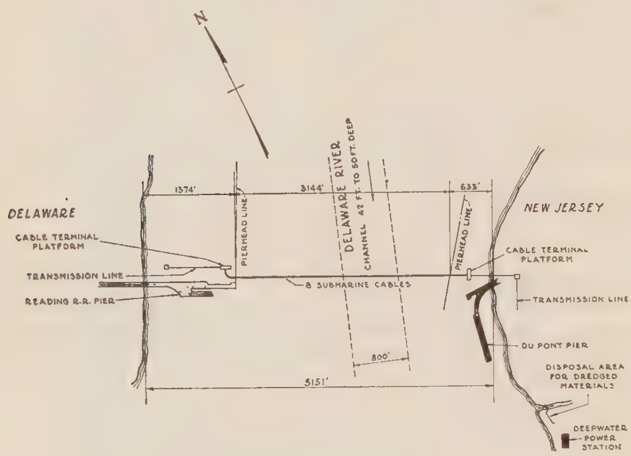

Fig. 1—Plan Submarine Cables

With certain minor modifications the cable was made according to the specifications of the Association of Edison Illuminating Companies.

Each circuit was designed to carry 60,000 kv-a. continuously, (525 amperes per conductor), with a resulting conductor temperature not to exceed 60 deg. cent. This rating was determined on an "in air" basis without steel armor, because operation is in air for an appreciable distance above the water at terminal points.

A comparison of the difference in the losses and first costs for bronze and steel armor was decidedly in favor of the steel, and accordingly, steel was used. There would be increased heating from the steel but for the major part of the cable which was immersed, this was inconsequential. However, for the short section out of the water between the river level and the cable potheads, additional heating due to steel was prohibitive. This difficulty could easily be met by removing the steel, but the protection of the lead sheath against mechanical injury developed a chain of very perplexing problems involving electrolysis, corrosion, and adaptability.

The sheath and armor losses are of particular interest; for spacings varying from 2 to 6 ft. and with cables in air, the manufacturers computed values ranging from 12.5 to 15 watts per ft. The test values of the cable in place on an average of 4-ft. spacing amounted to 10 watts per ft. This may be explained in part by the fact that the submerged cables are subjected to an envelope of brackish conducting water, the effects of which could not be taken into account in the calculations. The dielectric loss was very small, being about one-third of a watt per ft. at 75 kv., and a copper temperature of 40 deg. cent.

Due to the importance of the installation and the question of the respective merits of the various products, one circuit and spare cable were purchased from each of two manufacturers. The cable was manufactured in eight lengths, (each length complete without splices), and wound on reels having a total weight of 46 tons each. Each piece was 4050 ft. long, from which approximately 125 ft. were taken for test purposes, leaving a net length of 3925 ft.

The cables were terminated in potheads of the 110-kv. outdoor porcelain type, oil filled, and so constructed as to provide for ample expansion of the copper conductor apart from any other portion of the cable.

The standard pothead design was slightly modified by replacing the usual glass oil reservoir at the top by one of all-metal oil-tight construction. A six-gallon oil reservoir under a pressure of 7 lb. was connected to the cable immediately below the pothead to insure against the running of the cable compound and voiding the insulation particularly the portion emerging from the river.

These cable potheads were mounted on the terminal platforms (Fig. 3) which also supported the transmission line dead-end towers, a structure for the operation of the spare cables and bus, a small gantry crane, and a deck house for telephone and repair equipment.

Mechanical Protection of the Cable

Due to vessel anchors dragging across them, cables previously laid near the proposed location were subject to excessive service interruptions.

Marine authorities were consulted as to the action and penetration of dragging anchors, but even fairly accurate information was not available. Therefore it was decided to conduct a series of experiments based on two methods of protection:

1. Placing the cable in an excavated and backfilled trench at a depth greater than anchor penetration.
2. Laying cables directly on the bottom between two

rows of steel sheet piling, flush with the river bottom.

These experiments showed that the dragging of anchors was a real menace to the cables; that anchors, except possibly under extraordinary conditions, could not penetrate further than their flukes, or 8½ ft. for the largest anchors normally used, and that the the placing of sheet piling in rows was not effective. Therefore it was decided to install the cables in a trench 10 ft. deep and 40 ft. wide at the bottom, and to backfill it to approximately the original level.

Simultaneously with the above experiments, test borings in the river bottom were obtained and showed very unsatisfactory conditions. Three-fourths of the river's width from Delaware side had a plastic mud bottom; the remainder of the river bottom was of firm sand and gravel. This exploration gave rise to the question of whether or not a trench could be dredged and how long it could be maintained open for cable laying; therefore, further experiments were conducted as follows:

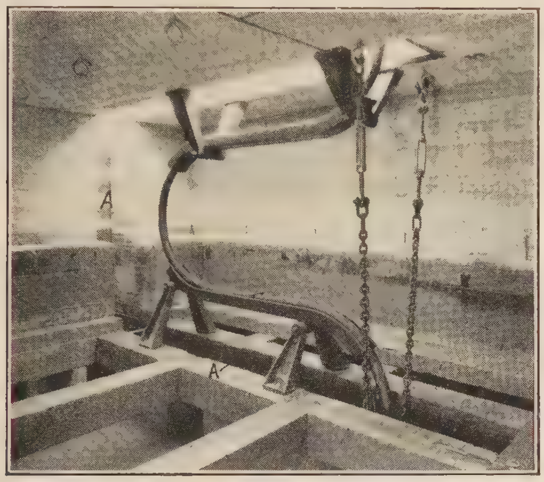

Fig. 2—Spare Cable Support and Slots

1. Dredging test trenches in mud and gravel sections of the river to determine the time that the trench could be maintained open for cable laying.
2. Dredging test trench in the river bottom between rows of sheet piling to ascertain the effectiveness of piling in retaining the slopes and preventing resilting.
3. The handling of cable laying, or derrick boat across the river for determining alinement, method, and accuracy of travel.

Contrary to the conclusions drawn from the test borings, the results indicated that there would be no difficulty in excavating a trench in the mud with a side slope of one and one-half to one, and with practically no evidence of resilting. However, the velocity of the river eroded the sides of the trench into a very long slope, thus tending to form a new river bottom which if allowed would increase the backfill required or decrease the protection. On the New Jersey side the sand and gravel trench sides held up, but "silted in" about as rapidly as the erosion of the side walls in the mud section. Soundings in the test trenches over a short period indicated that the trench in both the mud and gravel would not remain in a satisfactory condition for more than approximately from 45 to 50 days, and that unusual efforts would be required to remove and dispose of 205,000 cu. yd. of excavation and lay the cable in that period.

Cable Terminal Platforms

Since the cable was of insufficient length to reach entirely across the river, it was necessary to build concrete island platforms just inside the pierhead line to carry the cable potheads and other necessary equipment.

From the beginning it was recognized that this structure would have to be constructed with open slots from and through the piling, straight up to the top of the concrete deck, so that the cable could be "rolled" or placed in position without the necessity of "threading" under the piling and up through the platform as shown at *A* in Fig. 2.

The foundations were of wood piling and timber work. On this, the platform proper was carried in the form of a slotted concrete box, setting over corresponding slots in the piling and timber work (Fig. 3). Each platform has four compartments, completely "closed off" with concrete walls providing structural strength and safety against fire.

The spare cables can be used in any circuit by having each spare cable permanently connected to a spare bus and providing removable connectors in the vertical drops to the remaining six cables. In the event of failure of any one cable, its connector in the drop is removed and the upper part of the drop swung over to either spare bus.

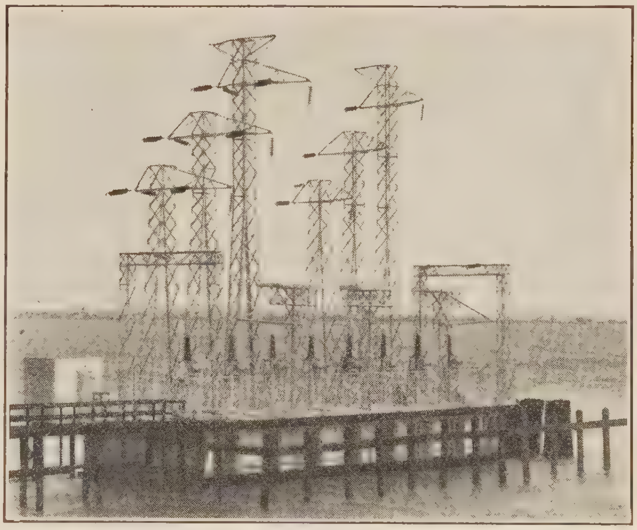

Fig. 3—Cable Terminal Platform

To comply with the heating conditions of the specifications, the armor was removed from that part of the cable in the air. The steel armor is terminated one foot below low water and lapped around three large cast iron flanges bolted together and suspended from the underside of the concrete platform by means of two chains and turnbuckles (Fig. 2), which provide an effective manner of dead-ending the steel.

As originally planned, the dead weight of the cable between the armor clamping flanges and the bottom of the pothead (22 ft.) was to have been relieved from the pothead by means of double-ear woven wire cable grips approximately 4 ft. long suspended inside the pothead support and immediately under the wiping sleeve of the pothead; but the cable was laid with such accuracy that approximately 190 ft. remained on each side. It was planned to utilize as much as possible of this extra length by providing loops in the cable in the compartments under the deck of the platforms. As shown in Fig. 2, this was accomplished rather easily by laying the spare cable in two cast iron troughs provided with wood shoes, treated to prevent battery action.

Electrolysis Protection

The removal of the steel armor from the cable necessitated the installation of non-magnetic protective armor after the cable was laid and placed in the slots of the platform. Many methods of accomplishing this were considered and experimented upon, but were found to be weak or practically impossible.

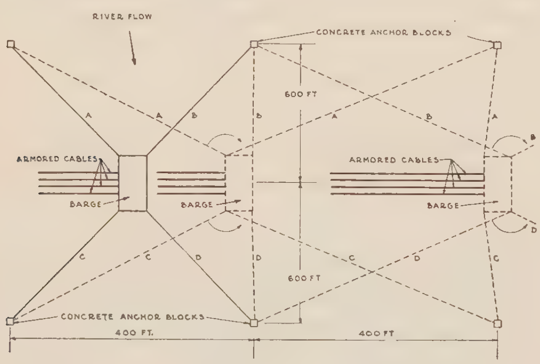

Fig. 4—Cable Barge Propelling Itself across River

Finally a method was devised that avoided all of the difficulties and was extremely simple in every way. This consisted of slipping over the cable a commercial, flexible, liquid-tight, bronze hose, to each end of which was fastened a coupling. This flexible hose was fastened to the armor clamping rings at the bottom, and stopped at a point just below the top of the concrete deck. The couplings at each end were made tight against the lead sheath over a lapping of asbestos tape. The hose, larger than the cable, was filled with a neutral grease and oil (through a grease fitting in the lower coupling) until it escaped from a relief valve in the top coupling. This proved to be very successful; the hose being strong, afforded every protection against ice and debris; the neutral oil and grease prevents the bronze from coming in contact with the lead and setting up battery action, and most effectively keeps out the river water, thus preventing electrolysis.

Construction and Installation

The construction work was divided into four operations; dredging, laying of cables, backfilling, and construction of cable platforms.

In order to avoid the results of sloughing and resilting of the trench, the cables were laid as soon as possible after trenching was completed which was considerably in advance of the completion of the cable platforms.

Trenching was carried on with five dredges operating day and night. The trench was approximately 40 ft. wide by 10 ft. deep, at a maximum depth of 62 ft. below mean low water and an average of 45 ft. The dredged material was barged down the river to a point in front of the new Deepwater Power Plant where a suction dredge rehandled the material and filled up the low land around the plant. Material to the extent of 205,000 cu. yd. was removed and disposed of in 43 days.

Considerable thought had been given to the handling of the derrick boat and cable laying, particularly to keeping it in as straight a line as possible. In considering this problem, it is well to have an idea of the magnitude of this particular part.

At ebb tide the river has a velocity of about 2½ mi. per hour; the wind and sleet storms in the fall and winter are severe, and at all times the river traffic is annoying and uncomfortably close. It was felt that it was best to lay four cables at a time, which gave approximately a 250-ton reel and attendant equipment load. A derrick of ample capacity had to be available to reclaim cable in the event of the boat getting off course beyond the trench, or upon the occurrence of an accident. Without allowances for deviation, there was but a difference of 209 ft. between the amount on the reels and the actual computed length of cable required. Consequently, the question of keeping the cable boat on a straight course was of outstanding importance.

The cables were laid four at a time, two trips being required to complete the operation. The cable reels were mounted on the bow end of a large derrick boat towed to one end of the trench immediately adjacent to the cable terminal platform, where the ends of the cables were taken off and placed in position on a temporary rack.

The boat was maintained lengthwise to the flow of the river (Fig. 4) and kept in line over the trench by means of two cables from the bow and two from the stern, fastened to anchors made of 30-ton concrete blocks. These anchors were set in two lines across the river, one line upstream and the other downstream from the trench. The rows of anchors were approximately 1200 ft. apart, with a spacing of 400 ft. apart in each row. The bow and stern lines of the derrick boat were wound on large drums and so connected to an engine drive on the boat that all four drums could be operated in any combination, in synchronism or separately. Thus the derrick boat, by the use of ranges and check methods developed especially for this service, pulled itself across the river and maintained itself on the established line. As the boat progressed across the river, the bow and stern lines were shifted from one anchor to another as shown in Fig. 4.

As the cables were being laid, they were frequently checked by a diver and later, by soundings which showed the cables to be 4 ft. apart and practically balanced across the center line of the trench, with a maximum deviation of any cable from a straight line not exceeding 6 ft. The experimental or trial run of this method indicated 150 ft. required for deviations, but in the actual laying, only 60 ft. were used.

This was the most important element in the satisfactory completion of the job.

Immediately following the laying, the concrete anchors were removed and the trench backfilled with sand and gravel.

The engineering features and the right of way were started in the spring of 1929, but nothing conclusive could be done until the right of way was determined in August, when the work was given a definite beginning and prosecuted vigorously in the face of approaching winter.

The dredging was started October 7, 1929, and finished November 25th. The cable laying was started on November 27th, the first run finished in 5 days and the second in 3½ days. The backfilling and cable platforms were finished on February 14 and March 7, 1930, respectively, and the cables placed in service March 9, 1930, a total elapsed construction time of 131 days.

This project was constructed for the Delaware Power & Light Company, subsidiary of the United Gas Improvement Company, by United Engineers & Constructors, Inc., and is operated jointly with the Philadelphia Electric Company.

Abstract of

THE ANALYTICS OF TRANSMISSION CALCULATIONS

The Theoretical Foundation of the Quaternary Linear Real Transformation Connecting Input and Output Quantities in the General Electric Circuit Together with Its Application by Algebraic and Geometrical Methods

By T. R. Rosebrugh*
Member, A. I. E. E.

THIS paper deals mainly with a more general and systematic method than has hitherto been used in handling certain classes of problems involving steady-state transmission calculations in terms of real quantities.

Part I is introductory, however, and demonstrates that the binary linear transformation which, in 1919, the writer showed to exist for all ladder circuits in terms of complex quantities and with determinant unity, also occurs in operational form for the general input-output network and likewise with determinant unity, thus including sine wave as a particular case.

Part II takes up the general case of input-output circuits under sine-wave conditions as a quatenary linear transformation in real quantities, likewise with determinant unity but subject to a certain condition ("absolute covariant").

The subject matter involves on equal terms, voltage squared (z), current squared (w), power (x), and reactive volt-amperes (y) for both input and output ends in the general circuit and in the special case of a transmission line, per se, it also introduces mean values of these quantities throughout the length of the line, suggesting the engineering importance of some of them.

For this latter purpose, the 16 real coefficients of the transformation are given as functions of s, the length of the line leading to their mean values as tabulated.

Twenty identities involving values of the "a-set" of coefficients which are useful for checking numerical values and simplifying unnecessarily cumbrous results are given as are also the relations between the "a-set" and the "b-set" coefficients. The diagram of the admittance plane is used and it is pointed out that it is also a three-origin vector diagram, the exact interpretation being given. A table of statistical data about the points of a "kite framework" shows in extremely simple form the proportionate values of each of the eight fundamental quantities at each of these points. There are eight fundamental circles in the plane and 28 families of simple ratio loci (circles), each family having its own radical axis. About half of these have obviously useful conceptions either in power or in communication engineering.

A wider point of view in which linear functions of the eight fundamental quantities are dealt with is now introduced and a classification made of problems of complete and incomplete data. The former may or may not involve maximum conditions. Problems of maxima may be one-conditioned or two-conditioned.

The type-cases of each are studied and the other cases reduced to the type.

One-conditioned maxima are associated graphically with (Poncelet's) limit points and analytically with a matrix which defines a line and three circles intersecting in these limit points.

Two-conditioned maxima are represented graphically by the points of intersection of a circle cutting three others orthogonally with one of the circles. Analytically the determinantal equation, rules for whose formation are given in each case, gives the radical center and the radius of the circle intersecting the other orthogonally.

Two simple examples are worked out algebraically and arithmetically. Acknowledgment is made of the assistance of Mr. V. G. Smith and Mr. G. DeB. Robinson.

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Presented at the Summer Convention of the A. I. E. E., Toronto, Ont., Can., June 23-27, 1930. Complete copy upon request.

Aeronautical Radio Communications

BY EUGENE SIBLEY[1]

Non-member

Synopsis.—In addition to the establishment of beacon lights and intermediate landing fields by the Federal Government, additional communication facilities are being provided which will meet the further demands of air transport companies operating under all conditions of weather on Federal airways. These facilities consist of a network of land line services, airways radio stations, and radio range stations along the airways for collecting and broadcasting weather information and for the guidance of aircraft by radio direction. Marker beacons are located at the intersection of the radio range courses to signal the pilot that his receiver should be adjusted to the frequency of the next radio range. These beacons also serve to give the exact location on the route.

The Bureau of Standards and other similar branches of the Government and private concerns are constantly engaged in research and development work.

The Federal Radio Commission's aviation plan provides for two-way communications with aircraft by the air transport companies. The aviation plan also provides for a system of communications between airports and aircraft. The services of these companies and airports are coordinated with the facilities provided by the Federal Government.

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PAST experience in providing aids to air navigation as well as future predictions of those interested in aeronautics indicate that aircraft will be obliged to look forward to radio as a means of providing dependable schedules and safety of operations. To meet the demands of operations on fixed schedules which must necessarily be encountered with all conditions of weather, the Airways Division of the Department of Commerce is establishing radio facilities consisting of a network of airways radio stations and radio range stations for the dissemination of weather information and guidance of aircraft over the civil airways. This program which contemplates the installation of approximately 70 airways radio stations and 110 radio range stations when completed will provide adequate weather reports and radio direction to all aircraft equipped with a simple type of radio receiver when flying the established airways of the United States. At the present time there are 39 airways radio stations in operation with 20 additional stations to be constructed and placed in operation during the fiscal year 1931. The program covering radio range stations for the fiscal year 1931 provides for 33 installations. Fourteen of these are now nearing completion which by January 1, 1931 will bring the total number of stations in operation to 53.

Sector weather information is collected along the civil airways by teletype, telephone, or telegraph from points approximately 60 miles apart, and broadcast hourly. In addition, the digest of weather conditions and forecasts prepared by the Weather Bureau every three hours from reports by the secondary network system of weather reporting stations is broadcast from the radio stations within the several zones, furnishing weather information covering areas 100 miles or more in width on both sides of airways. A simple receiving set aboard the airplane enables the pilot to be constantly advised of changing weather conditions and will do more than any other one factor to provide safety of flight.

The radio stations are operated in conjunction with the directive radiobeacon service being established along the airways. The radiobeacon is stopped and identified by station announcement, followed by the correct time and current weather information affecting the airway, in accordance with the weather broadcast schedule.

The equipment of a standard radio station of the Airways Division consists of a two-kw. intermediate-frequency transmitter for broadcasting the weather information and messages to airplanes for the safety of flight. In addition, a 500-watt high-frequency transmitter is used for point to point communications. This transmitter may be operated from an auxiliary gasoline engine generator in the event of power supply failure.

The directive radiobeacon, also known as the radio range, has proved to be a very important aid to safety in air navigation, and for this reason an extensive program covering the installation of aural type beacons has been actively started. The radio range has an advantage of serving the pilot throughout the 24-hour day, and unlike lighted aids to navigation is not affected by thick-weather. The most important feature of the radio range is that it serves as a homing device making it possible to fly to the exact location of the beacon, and thereby locate the landing field at which the radio range has been established. A number of landings under conditions of fog and thick weather have already been made in cases of emergency by aid of the radio range beacon and trips that would otherwise be impossible have been completed with safety.

The antenna system of the radio range consists of two crossed loops erected at right angles to each other and supported by poles. In a small building at the foot of the center antenna pole, a radio transmitter, goniometer and characteristic signal device are located together with other apparatus required for the operation of the beacon. The radio range transmits a character-

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istic signal alternately from the equivalent loops sending the letter A and N which interlocks, marking the radio course along the points of equal signal strength. The interlock signal is the letter T. There are four courses, each approximately three degrees in width, that can be shifted by means of a goniometer to coincide with the lighted airways. The conventional patterns of the directional radio range cannot be used at locations where there are bends in the lighted airway, however, the patterns may be altered by use of a vertical antenna in conjunction with the loop antennas and thus bend the radio courses at the beacon to make the radio courses coincide with the lighted airway. At other points it is necessary to change the intersecting angle of the courses, and this may be accomplished by introducing a resistance into one of the equivalent loops, thereby altering one of the patterns and thus, the position of the interlocking courses.

The radio range is operated in conjunction with radio telephone stations. The beacon is stopped and identified by station announcement followed by correct time and weather reports, and on completion of the broadcast, the operation of the beacon is resumed. This system has a number of advantages, in that the pilot does not have to change the tuning of the receiver and is listening at all times for either radio range signals or weather broadcasts; it is possible therefore to interrupt the beacon at any time and communicate emergency messages to the pilot in flight.

Experience in the operation of the aural beacons during the past year has shown that the letter A and N transmitted at a rate of 22 signals per minute are most effective and easy to follow. All beacons will use this combination of signals. This, in addition to the station announcements by voice, is made during the weather broadcasts every 15 minutes. For uniformity and purposes of orientation, quadrants north and northwest have N (dash-dot) signals.

The radio receiver required on board aircraft for the reception of weather broadcasts and radio direction consists essentially of a receiver, A and B battery supply, earphones, and antenna. The receiving equipment including power supply weighs approximately 30 lb. and has a frequency range from 200 to 400 kilocycles. The antenna consists usually of a streamlined wooden mast which extends about 6 ft. above the fuselage and is usually mounted to the rear of the cabin or behind the pilot, with the receiver directly beneath it. An insulated wire extends through the length of the antenna mast. It has been found desirable to insulate the antenna conductor from the elements to reduce *rain and snow static*. The receiver, which has an over-all amplification of about one million, may be remotely controlled and can be used by either single or co-piloted airplanes.

In addition to the foregoing radio aids to air navigation, it has been found desirable to provide two-way communication between aircraft and the ground for scheduled interstate operation, carrying passengers. To take care of this need for two-way communications, the Federal Radio Commission has approved the aviation plan which provides for the reservation of frequencies for aviation purposes designated for three classes of service: First, frequencies used by aeronautical chains and aircraft stations over designated routes; second, frequencies used for distress, calling working, and navigational service; and third, experimental frequencies which include all communication frequencies other than those in use on a chain basis. The initial establishment of aeronautical chain stations cover the brown, blue, green, red, and yellow chains. Under this plan, the air transport companies establish the ground aeronautical chain stations along the routes served by the radio communication chains to provide adequate service without discrimination for all and any aircraft. Where the service provided by a chain is used regularly, as distinguished from casual, incidental, or emergency use, the owners of the aircraft which use such chains shall agree among themselves as to the operation, maintenance, and liability of the stations.

For use of all aircraft, a national calling frequency of 3106 kilocycles has been established. A national airport and landing field frequency of 278 kilocycles has been established for communications from the ground to aircraft, the power not to exceed 10 watts.

Every 15 minutes the radio range is interrupted and identified by voice, followed by a current weather report from the airways radio station making the broadcast. Once each hour a complete weather report covering the route flown is broadcast from the airways radio stations. Such messages as are required for the safety of flight will be accepted by airways radio stations and broadcast to the pilot in flight on the beacon frequency. For long messages which may interfere with the beacon service to other aircraft in the air, the operator will request the pilot to tune in on a working frequency within the beacon band. When passing over intermediate landing fields designated as position-reporting stations, the pilot will receive a marker beacon signal on the beacon frequency giving him his location along the route.

At the intersection of radio range courses and other critical points, radio marker beacons which in addition to transmitting the distinctive code signal serve as mileposts along the route, are equipped for voice communication and are used for acknowledging "plane over" movement messages from aircraft flying over the route. Teletype machines are being installed for the collection of weather reports every hour, and the "plane over" reports are transmitted on the teletype to the terminals. The airways keepers stationed at these weather collection and position-reporting points maintain a watch throughout the 24 hours of the day. By the end of the fiscal year, 1931, there will probably be about 99 marker beacons in operation on the Federal airways.

When passing over airports equipped with low-

power radiotelephone transmitters, the pilot should tune the beacon receiver to 278 kilocycles for such communications as may be transmitted from the airport. Landing instructions and other emergency messages will be transmitted from the airport manager on 278 kilocycles. During the next year a number of airports will be equipped with radio transmitters and receivers for two-way communications with aircraft. Aircraft bound from one point to another passing over a number of airports will be able to establish communications and learn of changing weather conditions and information required for the safety of the flight. Several manufacturers have perfected beacon receivers which are entirely practical and suitable to take full advantage of the radio aids to air navigation operated and maintained by the Department of Commerce.

To complete the system of two-way communications between aircraft and the ground stations, aircraft must be equipped with a radio transmitter in addition to a high frequency receiving set. The simplest type of transmitter suitable for the small airplane is a radiotelephone transmitter of about 8 watt power, built to transmit on a single frequency of 3106 kilocycles, which is the frequency established nationally for calling and distress messages. This transmitter with the simple beacon receiver provides two-way communication at short range. When passing over airports, this equipment provides transmission on 3106 kilocycles to the airport from the airplane and reception from the airport on 278 kilocycles. This transmitter when used aboard aircraft enables the pilot to communicate with airways keepers at principal intermediate points along the route, transmitting "plane over" reports and emergency messages to be relayed to the terminals by teletype. In cases of emergency, communications to other aircraft can be made through the ground stations. In addition, the aeronautical chain stations operated by the air transport companies stand a watch on 3106 kilocycles for emergency communications from aircraft.

For air transport operations involving constant contact with aircraft in flight, the communications are established through the aeronautical chain stations provided under the plan of the Federal Radio Commission. The transport planes which take full advantage of radio are equipped in addition to the beacon receiver with a high-frequency receiver and transmitter capable of operating on the assigned chain frequencies. The high-frequency receiver is so arranged with respect to the beacon receiver that the pilot may listen to either or both. By means of a selector switch, it is possible to utilize either one or both of the receivers, thereby making it possible to concentrate on the message of most importance to the pilot and safety of the aircraft. Experience to date indicates that at all times while flying over the route the radiotelephone transmitter should have a minimum power of 50 watts for maintaining contact with the aeronautical chain stations. Should a radio operator or co-pilot be carried, having the necessary radio operator's license, a 20-watt telegraph transmitter may be used, with equivalent results. The air transport plane, equipped with the two receivers and a high-frequency transmitterf receives all of the radio direction and weather service from the Department of Commerce stations and maintains constant contact with the management of the company through the aeronautical chain station.

In addition to the radio range system now being established to furnish radio direction between the air terminals over the federal airways, the necessity for providing a system for blind landings at airports under conditions of low ceiling, has presented itself.

The research division of the Department of Commerce is carrying on a program of research on blind-landing systems for use at airports. Such systems in general include three elements, or their equivalent, to indicate the position of the aircraft in three dimensions as it approaches and reaches the point of landing. In the present experiments, lateral position—that is, the landing field runway direction—is given by a small directive beacon similar to that used for guidance along the airways, but of lower power. Longitudinal position (approach) is given by marker beacons. Height is given by an inclined high-frequency radio beam. The runway localizing beacon and the marker beacons are identical in principle with the range beacons and marker beacons, respectively, developed for use in flying from one airport to another, and operate in the same band of medium frequencies. The landing beam used in present experiments operates on about 80,000 kilocycles. It is directed at a small angle above the horizontal, and is used in such a way as to provide a very convenient gliding path for the landing airplane, beginning at any desired elevation and any desired distance from the landing field. The airplane does not fly on the axis of the beam, but on a curved path whose curvature diminishes as the ground is approached. This path is the line of equal intensity of received signal below the axis of the beam. The diminution of intensity as the airplane drops below the beam axis is compensated by the increase of intensity due to approaching the beam transmitter. Thus, by flying the airplane along such a path as to keep the deflection of a microammeter on the instrument board constant, the pilot comes down to ground on a curved line suitable for landing.

The foregoing has set forth the active steps which have been taken to make the use of radio solve the problems of safety for air transportation. Just what the future holds in store in the way of providing safety of air transportation remains to be seen, but it is evident that it is through the development of radio aids to air navigation that the safety of flying will advance and develop into a stable transportation system.

Abridgment of

Transformers with Load Ratio Control

BY ARTHUR PALME[1]

Member, A. I. E. E.

***Synopsis.**—In the last eight years voltage regulation on transformers under sustained load has made rapid strides and found very wide application in extended power systems and on industrial loads. Originally it was found economical to equip for load ratio control only very large transformers using apparatus designed for high currents.*

This paper describes and compares with earlier developments a novel equipment of low-current rating that has been devised especially to control small blocks of power, thereby greatly widening the economic field of application of load ratio control. Particularly are the electromechanical features of this equipment stressed.

* * * * *

FROM a small beginning in 1923, the changing of ratio on transformers under load, or "load ratio control," developed rapidly until it has now become quite indispensable and without it, many a modern transmission system and network would be under a decided handicap. Reducing the amount of reactive kv-a. flowing between power stations, it increases the efficiency and the maximum output of systems; it allows a flexible tie-in between systems; and it finally offers a simple and economic method of regulating voltage for industrial loads.

Today, the following three methods are being used, classified according to basic principle:

1. A single winding with a tap for each voltage, two selector switches and two current interrupting devices. (Diagram 1*A*, Fig. 1).
2. A single winding with N taps for $(2\ N - 1)$ operating positions, two selector switches and two current-interrupting devices. (Diagram 1*B*, Fig. 1.)
3. A single winding with N taps for $(2\ N - 1)$ operating positions, with a current interrupting device for each tap. (Diagram 1*C*, Fig. 1).

Method (1) will give uniform steps in ratio under all conditions of load and power factor. Since the reactor is short-circuited on all operating positions, it does not increase the no-load loss on any ratio; nor does it add any reactive kv-a. to the system.

Method (2) has additional no-load losses and reactive kv-a. on alternate positions, and requires a reactor twice the size of that needed for Method (1); this introduces an appreciable transient drop in voltage during the process of changing taps.

Method (3) also gives additional no-load losses and reactive kv-a. on alternate positions; and furthermore, when loaded at less than unity power factor, gives incorrect or unequal ratio steps. This inequality of steps, therefore, makes it necessary to provide a greater number of steps for a specified voltage range than for Method (1).

The advantages of Method (1) were the deciding factors leading to the development of the apparatus herein described.

With a given standardized mechanical equipment, the cost of the load ratio control apparatus proper does not change materially with the amount of power handled. This means that the smaller the kv-a. rating of the machine to which it is applied, obviously higher will be its cost in percentage for the whole transformer. Considering, however, the many operating advantages which the installation of such a machine affords, this increase seems justified, provided the output of the transformer is not too small. Experience and past demand indicate that the majority of transformers which were equipped with load ratio control were of such size that the current to be handled by the selector switches and interrupting device was between 500 and 1000 amperes. Consequently, a line of apparatus was developed suitable for this range of current and for circuit voltages ranging from 15 kv. to 73 kv.

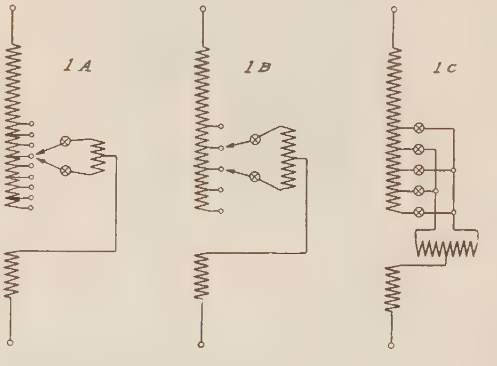

FIG. 1—THREE METHODS OF LOAD RATIO CONTROL, EACH FOR NINE VOLTAGES

Having established a firm foundation for heavy current apparatus, the demand for a similar equipment, suitable for much smaller currents and therefore smaller in size and lower in cost, became acute. With a load ratio control apparatus of such a type, the cost percentage of the switching equipment for relatively small transformers can be maintained at about the same economically sound ratio as for large units.

1. General Transformer Engg. Dept., General Electric Company, Pittsfield, Mass.

Presented at the Middle Eastern District Meeting No. 2, of the A. I. E. E., Philadelphia, Pa., October 13-15, 1930. Complete copy upon request.

Following this plausible route of reasoning, the existing heavy current type of load ratio control equipment has recently been augmented by a new line of apparatus for voltages up to 15,000 and currents not in excess of 400 amperes. Covering a period of several years with the heavy current equipment experience in the field justified the use of the same method of operation for the small type.

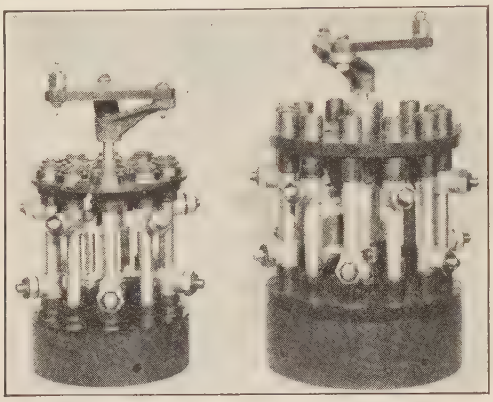

Fig. 2—Ratio Adjusters up to 1000 Amperes for 9 and 11 Positions, Respectively

A. Heavy Current Type

For current ratings up to 1000 amperes, the multipoint selector switch or ratio adjuster is a very substantially built device consisting of two molded compound heads into which are fastened securely 10 or 12 round copper rods. (Fig. 2.) To insure additional electric strength between adjacent rods, a short collar of "herkolite" surrounds each rod where it goes through the top and bottom head. In the center of this cage-like structure moves a set of copper contact fingers, each under the pressure of a strong helical compression spring. A combination of crankshaft and cam arrangement causes this set of fingers to slide on and off each rod as the center shaft is revolved, maintaining at the same time, however, permanent contact with the center which is connected to one of the 10 or 12 rods. From the taps in the transformer winding, cables of suitable size are carried to 9 or 11 of these rods. The wiping action of the fingers on each rod immediately before making final contact, and the mechanical sturdiness of the whole adjuster—the 10 point type weighs 82 lb. and the 12 point type weighs 116 lb.—are important features of these switches. Operating always under oil, the lubricating problem is easily solved. Mechanical life tests on these adjusters after half a million operations showed no visible wear.

For a single-phase transformer, two of these adjusters are required; for a three-phase transformer, two three-phase stacks are necessary. According to the cycle of operation, provision must be made to operate these adjusters intermittently; that is, on a single-phase transformer, one of them has to be reset at a time. On a three-phase transformer one three-phase stack must be reset at a time. This is accomplished by a specially designed *intermittent gear*, consisting essentially of a gear sector which when turned engages alternately with a small pinion at the right and one at the left, the two pinions transmitting their motion to the operating shafts of the ratio adjusters. As a rule gear and adjusters are mounted inside the transformer tank and form a self-contained unit with core and coils as shown for a single-phase example in Fig. 3, with the main driving shaft brought out, oil-tight, through the wall of the transformer tank.

Consistent with a maximum current rating of 1000 amperes, a heavy-duty current-interrupting device is fastened to the outside of the transformer tank. A special type of *oil immersed contactor* was developed for this purpose. The very high kv-a. rupturing capacity to which modern circuit-breaker designers justly point with pride is not required for the duty imposed upon breakers in circuits as in Fig. 1. Current carrying ability, good insulation to ground, short-circuit strength, and long mechanical life, are of sole importance. Life tests have indicated that for very frequent operation such as encountered in load ratio control, as compared with the only occasional opening of a circuit breaker on a line, a much longer life of arcing contacts results if they separate horizontally forward rather than downward, because the arc has less chance to burn the contacts.

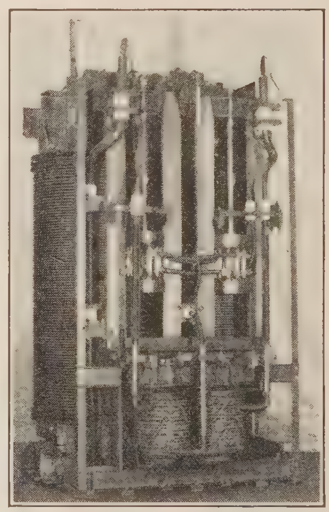

Fig. 3—Core and Coils for Single-Phase Transformer, Equipped for Load Ratio Control

Transformer rated 12,500/18,750 kv-a., 69,000 to 13,800 volts, with load ratio control of the 73-kv. type in the high-voltage winding

These considerations have led to the design of a single break, forward motion, double contact type of contactor—one pair of contacts to carry the current under normal operation, and one pair of arcing contacts. The contactor unit is mounted on two heavy type, petticoated porcelain through-bushings, which are bolted to a thick steel plate. (See Fig. 4.) For

single-phase transformers, such a steel panel carries two contactors; for a three-phase machine, six contactors. A scroll cam having two steel rollers moving in its groove, together with two sets of toggle levers, translate the rotating motion of a vertical drive shaft

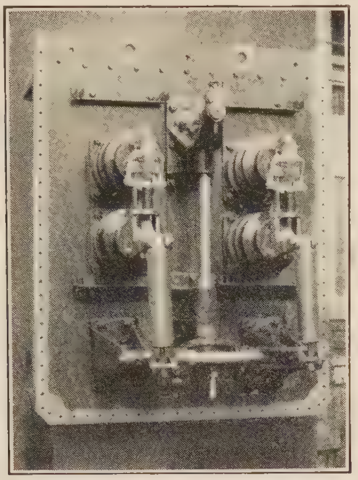

Fig. 4—Single-Phase Contactor Panel for 37-Kv. Circuit and up to 1000-Ampere

Oil tank removed

into intermittent opening and closing of the contactors. While the steepness of the groove in the scroll cam determines the *closing* speed of the contactors, their *opening* is made trip-free and very fast by the roller upsetting the toggle. Mechanically, the whole arrangement is very simple. Depending upon the cir-

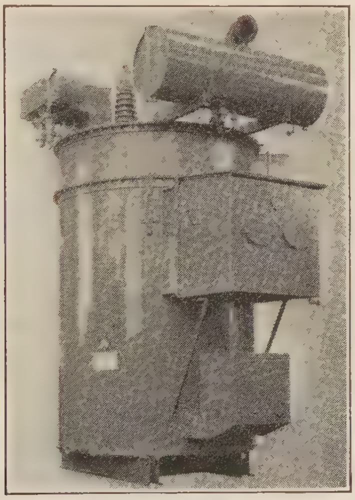

Fig. 5—External View of Single-Phase Transformer with Load Ratio Control

Transformer rated 20,000-kv-a., 132,000 grounded Y to 22,000 volts

cuit voltage, these contactors can be mounted on porcelain bushings for 15-, 37- or 73-kv. operating voltage. Contactors of this type are capable of rupturing 1000 amperes at least 7500 times with one pair of arcing tips, representing an average useful life of over two years, at the end of which time the two pairs of tips per phase can be readily and cheaply renewed. Enclosing the contactors and bolted, oil-tight, against the main steel panel, is an oil tank. For the three-phase type, insulating flash barriers are placed between phases.

For the remote operation of these mechanisms is provided a powerful *motor drive* located underneath the contactor tank. In addition to the customary accessories, such as a motor reversing relay, positioning controller, limit switch, dial for local and remote position indication, etc., the drive contains also an automatically-operated clutch which if an attempt should be made to run it beyond limiting positions disengages the motor. Worthy of note also is the introduction of electrodynamic braking of the motor which insures prompt stopping without the necessary maintenance of brake bands. A weatherproof and dustproof housing encloses the motor drive.

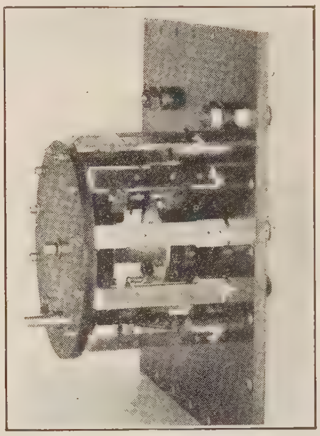

Fig. 6—Twin Ratio Adjuster for Nine Operating Positions and up to 400 Amperes

Fig. 5 shows the external appearance of a complete, heavy current type of load ratio control transformer.

B. Low Current Type

The main difference between the heavy current type and the new equipment for lower current and voltage lies in the simplified type of selector switches (ratio adjusters) in a smaller type of oil immersed contactors, and a smaller motor drive.

1. Ratio Adjusters. To comply with the diagram 1A, Fig. 1, two ratio adjusters or selector switches are required, the individual points of which are connected to one set of transformer taps. To insure the proper mechanical sequence of operation, provision has to be made to move these two sets of switches one at a time. To accomplish this in the large type of apparatus, an intermittent gear is used. In the smaller sizes it has been found possible to combine two ratio adjusters and the intermittent gear into one piece of apparatus called a "twin ratio adjuster." (Fig. 6.) The construction comprises essentially two dial type

switches, each operated by a Geneva stop gear and a driving pawl. When turning the main driving shaft one complete revolution, each dial switch will be moved a definite angular distance from one tap contact to the next.

The new dial switches have stationary knife contacts and movable but *self-alining* clip contacts. Pressure on the clips is maintained by reliable helical compression

Fig. 7—Single-Phase Contactor up to 400 Amperes

Removed from oil tank

springs. The stationary contacts are copper bars to which are welded suitably located copper blades. Nine of these copper bars are held in cage-like fashion between two heavy compound end plates. The moving clip contacts are attached to two molded compound

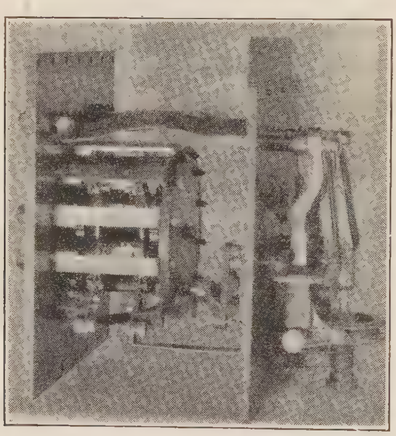

Fig. 8—Assembly of Twin Ratio Adjuster and Contactor for Single-Phase Load Ratio Control

Removed from its oil tank

Geneva gears, each with nine scallops corresponding to the nine fixed contact bars.

A twin ratio adjuster of this type therefore represents a very compact unit giving the two sets of contact fingers and the desired intermittent motion in a mechanically simple way. The wiping nature of the contact assumes excellent current-carrying ability, which further improves with use. In case of a short circuit, electrodynamic stresses are entirely eliminated, since the contact clip grips the stationary blade from both sides. Tests with over 25 times normal current (more than 10,000 amperes) showed neither welding nor sputtering. One such unit is required for a single-phase transformer; three of them for a three-phase machine. In the latter case, the three twins are gang-mounted in a straight line, with insulating couplings between them. It is customary to use the rear plate of the twin adjuster as an oil-tight window fitting over an opening in the upper part of the transformer tank so that the adjuster is mounted outside of the main tank in its own oil tank.

2. Contactors. The current carrying and current interrupting duty of these new smaller equipments being limited to 400 amperes it becomes possible to simplify the design of the contactors. (See Fig. 7.) To investigate the possibility of carrying and arcing on the same pair of contacts, a great many laboratory tests were made with very satisfactory results. Even at

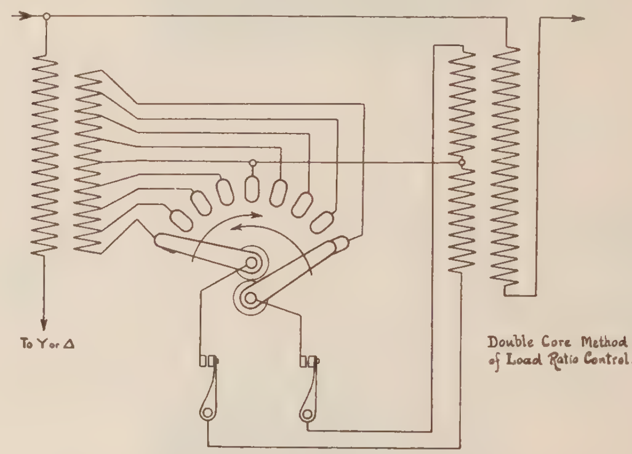

Fig. 9—Single-Phase Diagram for Double-Core Method of Load Ratio Control

double the rated current (800 amperes), thermocouples fastened to well worn tips recorded no undue temperature rise of the contacts after several hours. Consequently, the new light-duty contactor was made with only a single pair of contacts per pole.

The design of these contactors is made so as to open forward in a nearly horizontal plane. A further simplification was made possible by mounting the contactors on an insulating panel without the use of porcelains and by using insulating arms on the contactors.

A circular metal scroll cam located between the two contactors accomplishes enforced opening and closing of the two contactors in proper and definite time sequence with the twin ratio adjuster which is driven by the same shaft.

The contactors, with their simple cam mechanism, are located in a small cubical steel tank which contains also the twin ratio adjuster already described. The arcing of the contactors gradually carbonizes the oil thus necessitating two precautions:

1. That all insulating surfaces be in a vertical position to prevent carbon depositions.

2. That the oil in the arcing compartment be prevented from mixing with the oil in the ratio adjuster compartment.

Fig. 8 shows a view of the assembled ratio adjuster and contactor panel taken out of the oil tank.

For certain transformer connections, particularly for double-core transformation on very high-voltage regulating transformers shown in Fig. 9, it becomes necessary to move the two contact arms of a twin ratio adjuster in opposite directions. This is accomplished readily by the introduction of a pair of reversing bevel gears.

3. *Motor Drive.* Depending upon local circumstances, various methods of remote motor control are applicable to this small load ratio control equipment. A bank of three single-phase transformers can be operated by *one* motor drive with interconnecting shafts between the three units. This results in lowest cost, great simplicity, and absolute synchronism of the three phases. Universals and slip-joints in the interconnecting shafting make misalinements in the set-up of the individual transformer units of no consequence. It is also possible to provide each single-phase unit with its own individual motor drive, all of them connected to a common control switch so that they all pick up together and complete their cycle of operation as governed by a controller on each unit.

Bibliography

Covering signed articles on the subject of changing transformer taps under sustained load, as published in the technical press since 1925 and disregarding only anonymous articles which have appeared occasionally in European trade journals, a helpful bibliography is given in the complete form of this paper.

Metal Clad Gum Filled Switchgear

BY L. B. CHUBBUCK[1]

Member, A. I. E. E.

Synopsis.—*Metal clad gum filled switchgear has recently been developed using well-known standard American types of round tank, oil tight oil circuit breakers. This metal clad gear has important advantages over previous types of open or cell gear in the features of safety, compactness, service, maintenance and installation.*

Busses, etc., are mounted on micarta and are insulated and sealed in a gum of high dielectric value. The oil circuit breakers are raised to their bus contacts either by means of a common truck or by individual lifting mechanism per compartment. Very compact accessories, such as oil disconnecting switches, potential transformer assemblies, etc., are used.

With the high factor of safety provided for the bus, etc., the old standard double-bus scheme is not necessary as a spare bus, though a transfer bus is valuable to permit inspection of any breaker without interruption of service.

A description is given of various installations, including the large isolated-phase, outdoor switchgear under construction at Leaside Station, Toronto.

WHILE metal clad gum filled switchgear of European design has been in use for a considerable time, it is only recently that United States and Canadian designers have developed switchgear of this general type, incorporating, in it however, the well known American types of oil circuit breakers, etc. The large oil filled installation at State Line Station[2] was described at the Winter Convention and a description will be given in this article of a few other installations illustrating one general line of this equipment developed to date.

The advantages of metal clad gum-filled switchgear may be briefly enumerated as follows, as compared with the usual forms of open or cell type gear.

Safety. All live parts are fully enclosed in grounded metal casing, and interlocked to prevent operating mistakes.

Compactness. The self-contained metal clad equipment requires much less space and building expense, particularly as compared with masonry cell structures. With metal clad gear, the instrument panels are often mounted directly on the structure.

Continuity of Service. Bus insulators, busses, etc., are immersed in gum and are free from dust, moisture, smoke, vermin, or secondary short circuits due to ionized gas. The insulated bus, mounted on micarta supports under gum, provides a very high factor of insulation, and during voltage surges, the time lag under gum is much greater than for air. The gum provides a mechanical buffer for the busses, etc., under short circuit conditions, and the use of non-brittle micarta supports in a substantial metal structure gives a high factor against mechanical failure.

Maintenance. Should be a minimum for reasons given above, also due to provision for easy removal and replacement of the oil circuit breakers for inspection, etc.

Installation. As metal clad gear is factory built and shipped completely wired, minimum time and expense is required for installation. Where the instrument and control panels are mounted on the structure no small wire conduits are necessary in floors, etc.

General Construction. Metal clad gum filled switchgear is manufactured in two distinct types; *viz.*, the

1. Switching Equipment Engineer, Canadian Westinghouse Co., Ltd., Hamilton, Ont., Canada.

2. *Metal Clad Switchgear at State Line Station*, by A. M. Rossman, A. I. E. E. Quarterly TRANS., Vol. 49, April, 1930, p. 397.

Presented at the Summer Convention of the A. I. E. E., Toronto, Ont., Canada, June 23-27, 1930. Printed complete herein.

horizontal "drawout" type and the "vertical lift type." The two large American electrical manufacturing companies have standardized on the latter type for the following reasons:

(a) The vertical lift type requires less floor space. (b) Standard oil circuit breakers can be used with their direct short vertical bushings. The horizontal "drawout" type requires long special bent bushings, compound filled and covering over the breaker top. Bushing insulation is more difficult and the moving breaker is heavier. (c) In the vertical "lift" type the circuit breaker bushings are located under the bus structure, and are better protected and more drip proof. This type can readily be arranged for outdoor operation.

FIG. 1—TYPICAL 4000-VOLT INDOOR, METAL CLAD, GUM FILLED SWITCHGEAR IN HAMILTON SUBSTATION SHOWING BUS STRUCTURE, INSTRUMENT PANELS, OIL CIRCUIT BREAKERS, ETC.

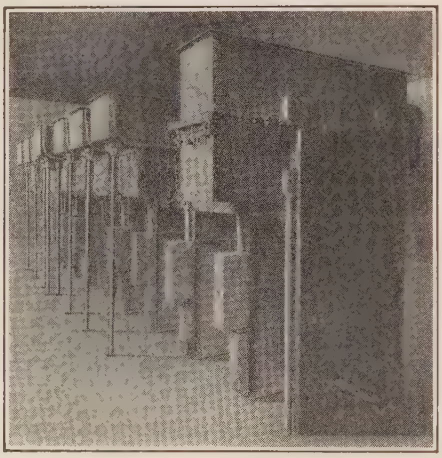

FIG. 2—REAR VIEW OF SWITCHGEAR SHOWN ON FIG. 1

This view shows the oil disconnecting switches for transfer bus, cable connections, contactor boxes, conduit, etc.

Construction Details. Bus bars are of copper insulated with micarta and supported in vertical micarta plates. The busses are also supported by their connection to the vertical bushings which extend downwards through the bottom of the bus boxes and make connection to the circuit breaker bushings. Because of brittleness and a possibility of cracking when filling the compartments with gum no porcelain is used for any of these bushings or bus supports. A special mixture of gum is used of normal rubber consistency, that will not crack at low temperatures, and that will not become fluid under outdoor summer conditions. The dielectric strength of this gum is approximately 100 kv. for half-inch. This gum filling as compared with oil obviates possible trouble with leaky gaskets. In the remote possibility of failure in any bushing or other part under the gum, the surrounding gum can readily be cut out with a heated knife without draining a whole section. When current transformers are located in gum compartments it is customary (for accessibility) to use a thin gum such as petrolatum in these compartments. Where possible, a preferable arrangement is the use of bushing current transformers on the oil circuit breakers.

Equipment. Modern oil circuit breakers of iron clad oil-tight round tank construction, are the standard types used in metal clad gum filled switchgear. These breakers have been well tested for interrupting capacity in high power test laboratories, and have a safety factor in accordance with this type of switchgear. The breaker vents for indoor service are connected to a header to carry expelled gas away from the structure. For outdoor service, each pole is vented to the outside and rear of the structure.

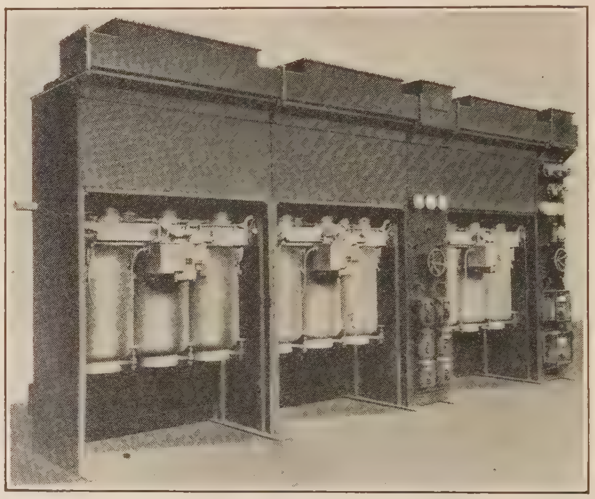

FIG. 3—TYPICAL 15,000-VOLT, INDOOR, METAL CLAD GUM FILLED SWITCHGEAR, SHOWING BUS STRUCTURE, OIL CIRCUIT BREAKERS, INSTRUMENT PANELS, ETC.

The breakers are usually handled on geared lifting trucks, motor-operated for the larger breakers. In some of the larger installations, an individual motor lifting equipment has been furnished for each breaker. This, while more expensive than a common truck, is better for outdoor service and permits remote control from the control board. It is usual to use remote control for the breaker between the top "operating"

position and the "maintenance" position, or low enough for the shutters to close. Below this position the maintenance man can take the control at the structure and lower the breaker further for dropping tanks, etc. With all forms of lifting devices, full mechanical interlocks are provided to prevent incorrect operation.

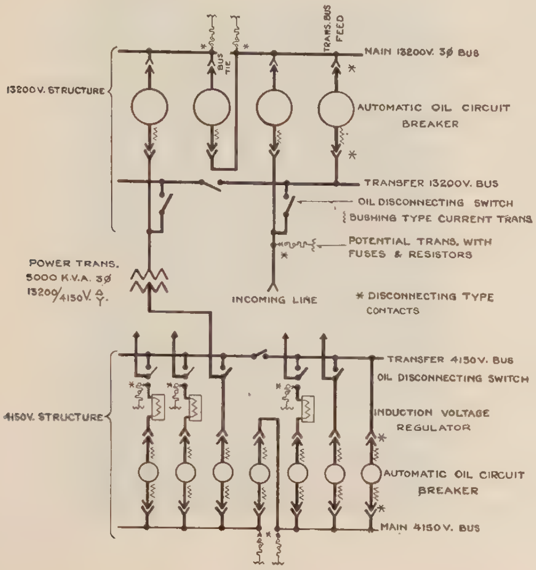

Fig. 4—Toronto Hydro Commission, Glengrove Station

Single-line diagram showing transfer bus scheme. Any breaker may be removed for inspection without interrupting service on that circuit. This is a large indoor, metal clad installation, 13,000-volt structure, length 114 ft.; 4150-volt structure, length 112 ft. The equipment will control 6 transformer banks, 13—13,000-volt circuits and 22—4150-volt circuits.

Automatic shutters are also used to close the openings to bus contacts when the breaker is in a lowered position.

In addition to the disconnect feature obtained by dropping the breaker below the shutters, a considerable number of disconnecting switches is usually required for bus sectionalizing, transfer bus connection, etc. In gum filled switchgear, it would not be consistent to use ordinary open disconnecting switches, or such switches in plain boxes. A line of oil disconnecting switches of substantial construction has, therefore, been developed. These switches have breaker bushings, finger break contacts and are designed for building into metal clad gear. Either hand or motor operation is provided. The compact construction of these oil disconnecting switches is marked as compared with gang-operated open type construction with barriers or cell work.

The potential transformers used for metal-clad gear also give much greater compactness and safety than the usual open construction with its separate fuses, resistors, disconnecting switches, barriers, etc. For the usual 15,000-volt three-phase service, the metal clad potential transformer unit will include in one tank, two single-phase transformers, three resistors, and three fuses—all oil immersed. The unit is provided with three bushings and can be plugged into the structure similar to a breaker. The three fuses are suspended from a small removable cover in the tank top so that the fuses can readily be withdrawn for inspection or renewal. In withdrawing these fuses they are automatically disconnected from the circuit.

Panels on which are mounted meters and relays can be added to a metal clad structure, thus providing a self-contained structure, completely wired and without the expense and complication of external small wire conduits. These panels are usually of steel and may be hinged to give access to their rear wiring or to the structure equipment behind them.

Cables leaving a metal clad structure are usually lead covered consistent with this grounded metal clad gear, though suitable bushings can be provided for overhead wiring. In the case of lead covered cable, small wiped joint fittings are furnished for attachment to the structure, the gum compartments in the structure providing ample space for sealed cable connection to the enclosed copper work.

Bus Schemes for Metal Clad Switchgear. While metal clad switchgear can be furnished for almost any scheme of station bus connection, yet due to the inherent safety and flexibility of this switchgear, a few, simple schemes are usually found adequate. With the sealed and high insulation factor provided for the busses, they require no attention or shut-down for maintenance. If the circuits controlled by the switchgear are in duplicate or may be disconnected at any time for inspection of a breaker, a single bus scheme may be sufficient. If on

Fig. 5—Metal Clad Switchgear in Supervisory Controlled Substation of the Winnipeg Hydro Commission

13,000-Volt switchgear on left, 4000-volt switchgear on right hand. Double-throw oil disconnecting switches are used on 4000-volt structure for induction regulator circuits

the other hand service must not be opened on any circuit, some form of transfer bus or ring bus is recommended. In Fig. 4 a simple transfer scheme is shown for the 13,000-volt circuits. In case inspection or replacement of a breaker is desired, the circuit is paralleled through an oil disconnect to the transfer bus, and

through the transfer bus breaker to the main bus. After this, the first breaker may be tripped and disconnected without interrupting service. In many metal clad switchgear installations this transfer bus scheme has proved very satisfactory. In Fig. 4, on the 4150-volt structure, a variation of this transfer bus

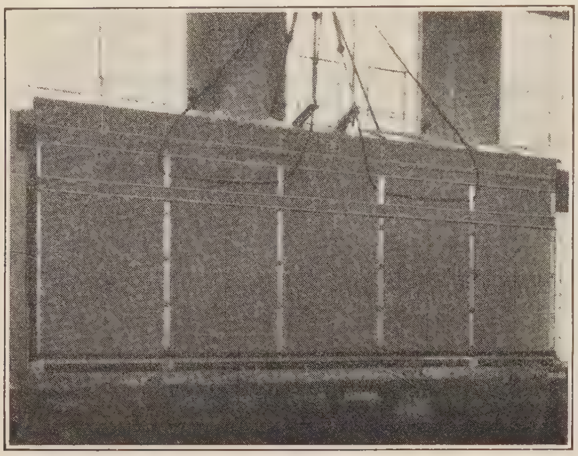

FIG. 6—OUTDOOR 15,000-VOLT, METAL CLAD, GUM FILLED, SWITCHING EQUIPMENT SHIPPED AS A UNIT

This equipment comprises five feeder breaker sections, with main and transfer busses and oil disconnecting switches

scheme for the induction regulator feeders is shown. Double-throw oil disconnecting switches are used for disconnecting the oil circuit breaker and induction regulator and throwing the feeder, unregulated, on to

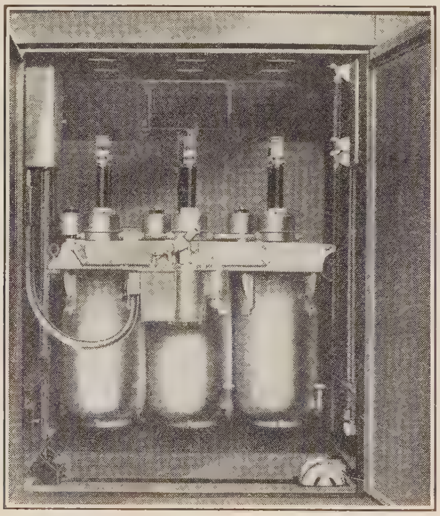

FIG. 7—INTERIOR VIEW OF ONE SECTION OF EQUIPMENT FIG. 6

The breaker (of 750,000-kv-a. interrupting capacity) is shown lowered below the shutters to the maintenance position. An individual motor lifting mechanism is used per breaker.

the transfer bus. This method is much simpler and safer than the collection of open disconnecting switches, etc., often located at the induction regulators.

Outdoor Metal Clad Installations. Vertical lift switchgear is readily adaptable for outdoor service as the standard indoor top and rear construction is practically waterproof. For outdoor service, particularly in Canada, it is advisable to supply tight fitting doors for the front of the compartments and in them use small electric heater units.

Leaside Station Switchgear. The Hydro-Electric

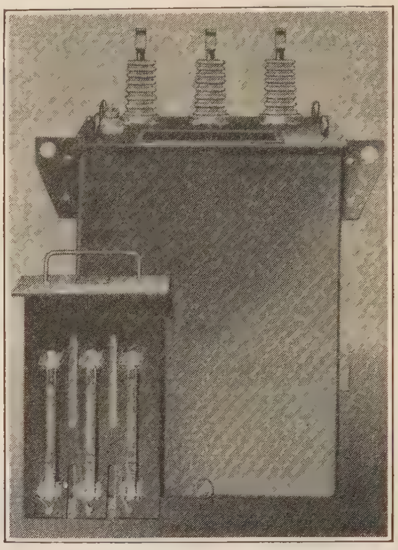

FIG. 8—POTENTIAL TRANSFORMER UNIT FOR PLUGGING INTO CIRCUIT

This unit contains two 15,000-volt potential transformers, three resistors, and three fuses, all under oil

Power Commission of Ontario is installing a large metal clad gum filled, isolated-phase, outdoor switching equipment at Leaside Toronto Station, to control the 13,000-volt connections from two 45,000-kv-a. banks of transformers. The initial 13,000-volt switching equipment for this station is of indoor type installed in a brick building; but for additional protection, safety, and economy, the Commission's engineers decided on the new design for the extension.

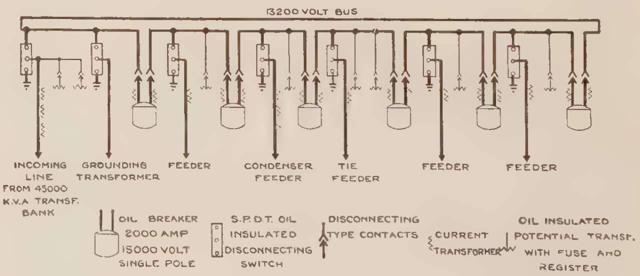

FIG. 9—LEASIDE STATION 13,000-VOLT EXTENSION

Switching equipment is isolated phase, metal clad gum filled, outdoor type. Three of the above single-phase equipments are required for each of the two banks of transformers now being installed.

Fig. 9 shows the main bus connections for one isolated-phase structure, three of these structures being used for each of the two banks of transformers. This provides a very flexible ring bus scheme with a minimum number of large oil circuit breakers. Any one breaker can be

disconnected for inspection without interrupting service on that circuit. In case of overload on a circuit, the two bus breakers on each side of this circuit are tripped; then, if desired, the oil disconnect on this circuit can be opened to clear this circuit, after which the above two breakers can again be closed to close the bus ring. In case of ground on that section very sensitive differential relay bus protection is provided to disconnect any bus section instantly. With this sensitive bus protection it was not considered advisable to install any fault bus scheme customary with an isolated phase installation. The fault bus scheme requires special insulation of structure, etc., from ground, and in case of trouble, would shut down a whole structure. Only a short bus section is disconnected using the differential relay scheme. The oil disconnecting switches on each circuit are double-throw so that connection may be made (a) to the bus, (b) open, or (c) to ground.

Figs. 10 and 11 show various elevations of the isolated phase structures. Aluminum alloy plate is used for the bus troughs, connection boxes, and roof. This provides against heating, rusting, and periodic painting. The busses are insulated with micarta, mounted on micarta plate and immersed in gum. A sample bus section successfully met a 100,000-volt five-minute insulation

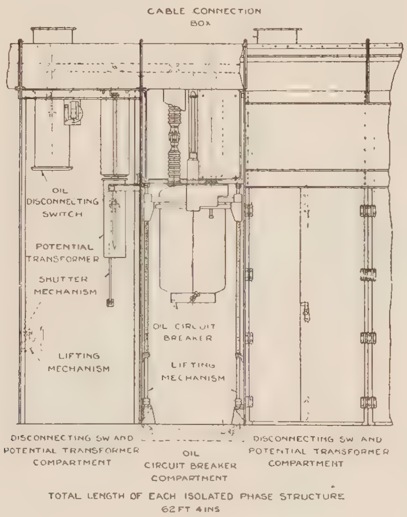

FIG. 10—LEASIDE STATION

Front elevation of 13,000-volt isolated-phase structure

test. A low temperature rise was also obtained on a trial run at 3000 amperes 25 cycles.

All bushings for oil disconnecting switches, oil circuit breakers, potential transformers and bus contacts are condenser type covered with porcelain on air ends.

The 2000-ampere 15,000-volt oil circuit breakers have a rated interrupting capacity of one and one-half million kv-a. They are of modern shaft-operated, oil-tight, round tank construction, with fabricated top and tank mechanism. Each single-pole breaker is provided with a geared motor-operated lift mechanism which can be operated from the board between the top and the "maintenance" breaker position if the breaker is in the tripped position. The operation once started continues until stopped by the limit switches. Below the "maintenance" position, control is taken at the breaker compartment.

The breakers are tripped or closed only from the control house. The three single-pole breakers on a circuit must all close at once, or the closed poles will trip out.

The oil disconnecting switches are single-pole, double-throw motor-operated and supplied in various current capacities up to 3000 amperes. Electrical interlocks

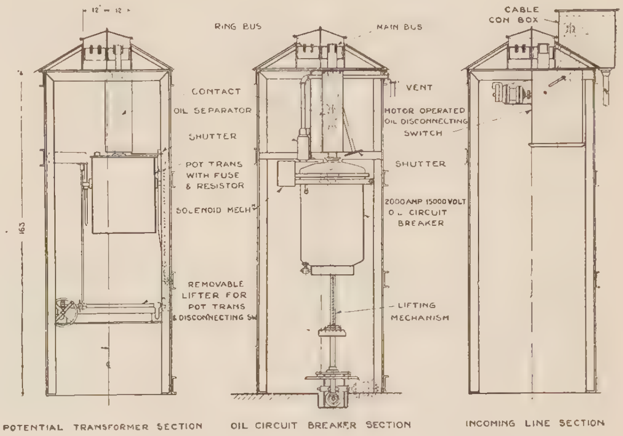

FIG. 11—LEASIDE STATION

Vertical sections through 13,000-volt isolated-phase structure

are provided so that there can be no operation of a disconnecting switch unless the oil breakers on each side of it are in the tripped position. The switches are controlled from the board from the closed to the open position and at the compartment from the open to the ground position.

The potential transformers are all single-phase units with resistor and fuse in the same tank. These transformer units plug into circuit and can be removed by a geared lifter.

The current transformers are all of bushing type, some mounted inside the oil circuit breaker tank tops and the remainder mounted under gum in the cable boxes.

In each structure compartment is furnished a control box containing contactors, knife switches, and terminal boards for all control and instrument cable for that compartment.

Conclusion. It is believed that metal clad gum filled switchgear offers decided advantages for most installae tions. For indoor service, it will generally replacr expensive or unsafe open construction. In outdoo-service, even for fairly high voltages, it is expected gradually to supersede the present steel work, open connections, and live equipment.

Abridgment of

A New System of Speed Control For A-C. Motors

BY A. M. ROSSMAN[1]

Fellow, A. I. E. E.

Synopsis.—*The drive unit of this system consists of a constant-speed a-c. motor supplemented by an adjustable-speed d-c. machine of much smaller size. Both rotor and frame of the a-c. motor are mounted on bearings. The d-c. machine is mechanically connected to the frame of the a-c. motor so that the d-c. machine may drive or be driven by the frame. The d-c. machine is electrically connected through a motor-generator set of equivalent rating, to the source of a-c. energy. The shaft speed of the a-c. motor is increased above the fixed speed by rotating the frame of the a-c. motor in the same direction as the rotor, and it is decreased by rotating the frame in the opposite direction. The direction of rotation and speed are governed by adjusting the voltage impressed on the armature of the d-c. drive machine by the generator of the motor-generator set. When the unit is used to drive fans, the speed range is obtained by a combination of armature voltage control and field control of the d-c. drive machine. This permits a still further reduction in the rating of the d-c. drive machine so that for comparatively wide ranges of speed, it forms but a small percentage of the total drive unit rating.*

Twenty-four units of this type, aggregating 7020 hp., are now being built for Powerton Power Station for driving forced and induced draft fans. This system of fan drive is being installed in preference to the two-speed squirrel-cage type induction motor system previously used, because it shows large savings in energy, costs little more, and provides a simple method of fan control which permits the adoption of a simplified system of automatic combustion control. The versatility of the system is further illustrated by a description of a 2500-hp. unit of this type designed to drive a high-pressure reciprocating boiler feed pump.

During the first seven months of 1930, orders were placed for 35 of these units ranging in size from 166-hp. to 2500-hp., aggregating 16,000 hp. for installation in four different power stations.

Description of the Motor and Speed Control Equipment

THE drive unit of this system consists of a constant speed a-c. motor of either the synchronous or induction type, supplemented by an adjustable speed d-c. machine of much smaller size. The frame of the a-c. motor is mounted on bearings so that the frame as well as the rotor may rotate. The d-c. machine which is shunt wound but separately excited is mechanically connected to the frame of the a-c. motor so that it may drive or be driven by the frame. The d-c. machine is electrically connected through a motor-generator set of equivalent rating to the source of alternating current energy. Fig. 1 shows a typical diagram of the machines with their electrical connections; Fig. 2 a typical arrangement of the drive unit.

Method of Operation

The speed of the driven machine is increased above the fixed speed of the a-c. motor, (which will be called the base speed) by causing the d-c. machine acting as a motor to drive the frame of the a-c. motor in the same direction as the rotor. The speed of the shaft is then the sum of the base speed plus the frame speed. The speed of the shaft is decreased below the base speed by causing the frame of the a-c. motor, acting as a motor to drive the d-c. machine, as a generator, in the direction opposite to that of the rotor. The shaft speed is then the difference between the base speed and the frame speed. The d-c. machine then delivers energy through the motor-generator set back into the a-c. system.

1. Research Engineer, Sargent & Lundy, Inc., Chicago, Illinois.

Presented at the Middle Eastern District Meeting No. 2, of the A. I. E. E., Philadelphia, Pa., October 13-15, 1930. Complete copy upon request.

The direction of rotation and speed of the d-c. drive machine are governed by holding constant excitation on its field and adjusting the voltage impressed on its armature terminals by the generator of the motor-generator set. The range of d-c. voltage is from maximum positive, through zero, to maximum negative. This voltage is controlled by a rheostat inserted in the

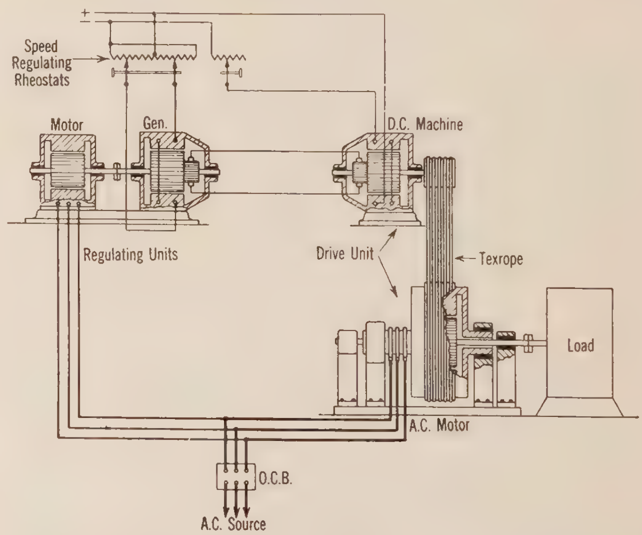

Fig. 1—Diagram of New System of Adjustable-Speed Drive

field circuit of the generator. The armature current does not reverse when the voltage is reversed.

Extension of the Speed Range

Where this system is used to drive fans (or centrifugal pumps), machines in which the power is a function of the cube of the speed, the speed range may be extended beyond that attainable by armature voltage control, by weakening the field of the d-c. drive machine. The field strength is controlled by a rheostat inserted

in the field circuit. Utilizing field control of the d-c. drive machine to furnish a part of the speed range decreases the spread between the rated speed of the a-c. motor and the maximum operating speed of the fan. As the apportioning of the rating of the drive unit between a-c. motor and d-c. machine is determined by the percentage of speed which each machine contributes to the maximum operating speed of the fan (coincident with maximum load), a decrease in the spread means a corresponding decrease in the percentage of rating of d-c. machine in the drive unit, and an equivalent decrease in the size of the speed regulating motor-generator set.

As the d-c. motor designed to give a 3/1 speed range by field control is a recognized standard machine, it has been chosen as the basis for determining maximum fan speeds corresponding to various speeds of the a-c. motor for those ranges of fan speed which exceed 100 to 57½ per cent. For ranges of fan speed less than 100 to 57½ per cent, the amount of field weakening must be reduced to prevent overloading of the d-c. drive machine.

Tabulations of Fan Speeds and Motor Ratings

Table II shows the maximum operating speed of the fan or pump, corresponding to the two variables which determine it, *viz:*

1. The speed of the induction motor;
2. The speed range of the load.

This table also shows the relative ratings of induction motor and d-c. machine, corresponding to each range of speed.

Attention is directed to the wide range of speed that can be obtained from a comparatively small percentage of d-c. machine rating in the drive unit. For example, a speed range of from 100 to 50 per cent is obtained with a drive unit in which the rating of the d-c. machine is but 13.3 per cent of the total. If the a-c. motor were of the synchronous type, the rating of the d-c. machine would be but 12.5 per cent of the total.

TABLE II

The following data apply to fans and centrifugal pumps, machines in which the power varies as the cube of the speed.

The table shows the maximum speed of the fan or pump corresponding to the two variables which govern it, viz:

1. Speed of squirrel-cage type induction motor.
2. The speed range of the fan or pump.

The table also shows for each speed range the relative sizes of induction motor and d-c. machine which together make up the drive unit.

The speed range is obtained by a combination of armature voltage control and field weakening of the d-c. drive machine. For ranges greater than 100 to 57.5 per cent, one-half the total range is obtained by each method. For ranges less than 100 to 57.5 per cent the proportion obtained by field weakening must be decreased to prevent overloading of the d-c. drive machine. The method of determining the limiting value of field weakening and the method of correcting for slip corresponding to variatons of load are given on the next table.[2]

Speed range—100 per cent to......(per cent)		95	90	85	80	70	60	50	40	30	20	10
Speed reduction in per cent of max. . (per cent)		5	10	15	20	30	40	50	60	70	80	90
Relative ratings of machines of the drive unit A-c.		97.4	95.1	93.2	91.6	89.5	88.7	86.7	84.1	81.6	79	76.5
Relative ratings of machines of the drive unit D-c.		2.6	4.9	6.8	8.4	10.5	11.3	13.3	15.9	18.4	21	23.5
Induction motor		Maximum operating speed of fan or pump										
Syn. speed	Full-load speed											
1800	1750	1800	1840	1880	1920	1960	1975	2025	2080	2150	2210	2300
1200	1160	1190	1220	1245	1270	1300	1310	1340	1380	1425	1470	1520
900	870	890	915	935	955	975	985	1005	1030	1065	1100	1135
720	690	710	725	740	755	775	780	800	820	850	875	905
600	575	590	605	615	630	645	650	665	685	705	725	750
514	490	505	515	525	535	550	560	570	585	605	620	640
450	430	445	455	465	475	485	490	500	515	530	550	565

[2]See unabridged paper.

Where horsepower varies directly with the speed, extension of the speed range by field control is not practicable; the full-load speed of the a-c. motor then becomes the mid-point between maximum and minimum shaft speed.

Equipment in the Powerton Power Station

An extensive installation of this system of speed control is now being made in the power station of the Super Power Company of Illinois at Powerton (near Pekin) Illinois. Here the forced and induced draft fans of six boilers are driven by motors which operate on this system. Each boiler has two forced draft fans and two induced draft fans. Each fan has its own independent drive unit. The a-c. motors of the drive units are of the squirrel-cage induction type.

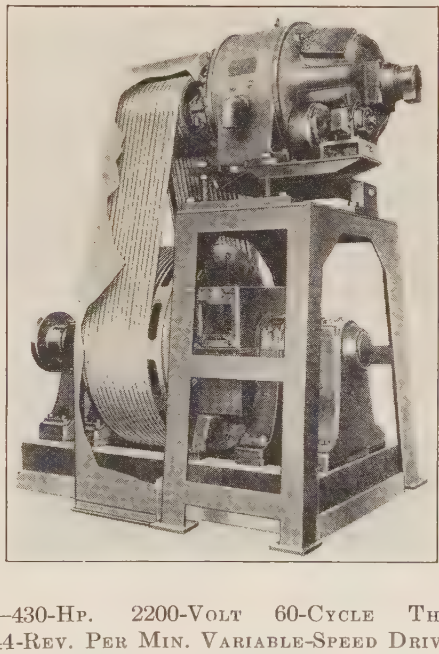

Fig. 2—430-Hp. 2200-Volt 60-Cycle Three-Phase 1088/444-Rev. Per Min. Variable-Speed Drive Unit

The frame and the rotor are supported independently,

each having its own pair of pedestal bearings. Hollow stub shafts, cast integrally with the end shield, support the rotating frame on the inner pair of bearings. The rotor is carried on a shaft which passes through the hollow stub shafts of the frame and is supported on the outer pair of bearings. All bearings are of the sleeve type. One of the hollow stub shafts is made sufficiently long to mount the three collector rings between the end shield and its bearing support. To prevent accidental contact with the live parts, the collector rings and brush rigging are enclosed in a steel housing. Fig. 2 illustrates the Powerton induced draft fan drive unit.

One motor-generator set controls the two forced draft fans of each boiler while a second motor-generator set controls the two induced draft fans.

The principal data pertaining to this installation are given in the following tabulation:

	Forced draft fans	Induced draft fans
Number of fans	12	12
Number of drive units	12	12
Maximum fan speed	1004-r. p. m.	1088-r. p. m.
Minimum fan speed	452-r. p. m.	435-r. p. m.
Range of fan speed	100% to 45%	100% to 40%
Constant-speed component (a-c. power) at maximum fan speed	141-hp. @860-r. p.m.	330-hp. @860-r. p.m.
Adjustable-speed component (d-c. power) at maximum fan speed	25-hp. @ 144-r. p. m.	89-hp. @ 228-r. p.m.
Total power at maximum fan speed	166-hp.@1004-r.p.m.	419-hp. @1088-r.p.m
Speed of d-c. machine at maximum fan speed	Plus 625-r. p. m.	Plus 625-r. p. m.
Speed of d-c. machine (operating as a generator) at min. fan speed	Minus 1875-r. p. m.	Minus 1250-r. p. m.
Ratio of ratings—d-c. machine/a-c. motor	14.5/85.5	21/79
Number of speed regulating motor-generator sets	6	6
Rating of each speed regulating motor-generator set	40-kw.	150-kw.
Total rating of all drive units	7020-hp.	
Total rating of all speed regulating motor-generator sets	1140-kw.	

The a-c. motors are designed to operate at 2200 volts, three-phase.

The curves of Fig. 3 show the division of load between the a-c. motor and the d-c. machine, over the speed range of the forced draft fans. These curves also show how the total speed range is apportioned between armature voltage control and field control of the d-c. drive machines. On the forced draft fans, one-half the speed range is obtained by armature voltage control and one-half by field control. The relatively small proportion of d-c. machines is reflected in the rating of the conversion equipment which as shown by the foregoing table is but 1140 kw. in motor-generator set capacity to control 7020 hp. in motor capacity.

Energy Saving of the New System at Powerton

An analysis of the application of this system to the fans of the six new Powerton boilers shows a distinct saving in energy consumption. Fig. 5 shows the horsepower input to each fan and the horsepower input to each motor at various fan capacities for the two different systems of driving the forced draft fans.

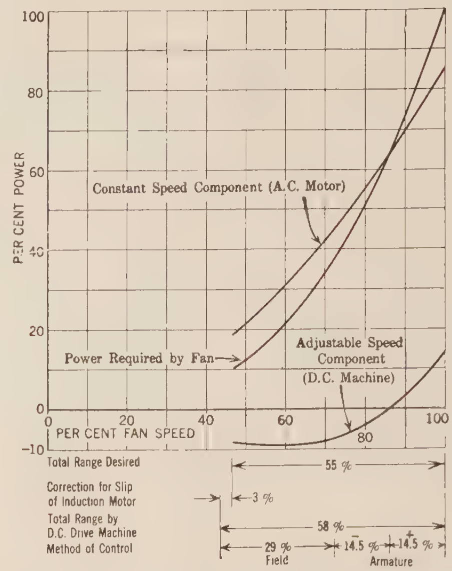

Fig. 3—Power Curves for Forced Draft Fan

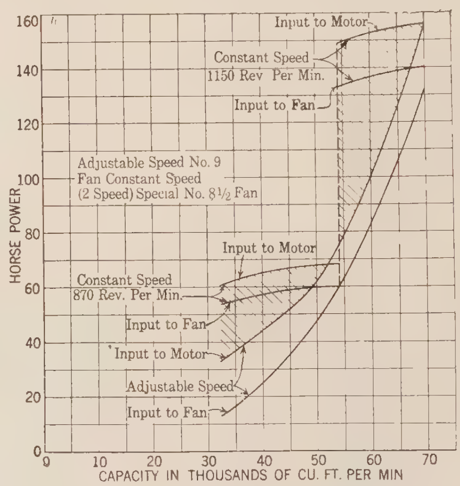

Fig. 5—Comparative Performance Curves for Forced Draft Fan

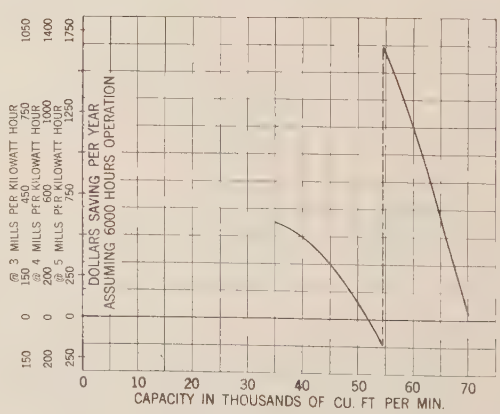

Fig. 6—Annual Saving for Standard Forced Draft Fan

Fig. 6 shows the saving in dollars of the new system over the old for a standard boiler at various fan capacities based on 6000 hr. per year operation.

Figs. 7[2] and 8 show similar curves for the induced draft fan.

Based on 8000 hr. of operation per year, Figs. 9 and 10 show the saving in dollars of the new system over the old for a reheat boiler with the forced draft and induced draft fans respectively.

From these curves are computed the following annual

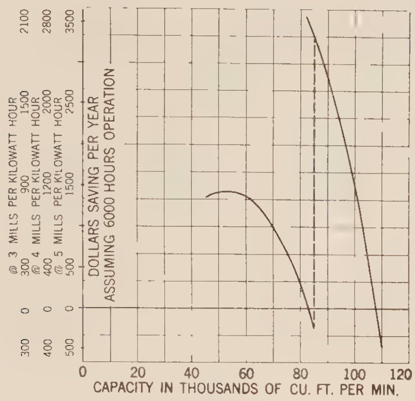

Fig. 8—Annual Saving for Standard Boiler Induced Draft Fan

savings (in dollars) of the new drive over the old for the fans of four standard boilers and two reheat boilers, based on three different unit costs of energy:

	Energy cost per kw-hr. 3 Mills	4 Mills	5 Mills
Annual saving for 12 forced draft fans	$ 4,535	$ 6,047	$ 7,559
Annual saving for 12 induced draft fans	8,780	11,707	14,634
Total saving for six boilers	$13,315	$17,754	$22,193

The detailed analysis of these figures is given in Table IV of the complete paper.

Cost of the New System at Powerton

Energy savings of this magnitude usually call for considerable additional expenditure of capital but in this instance, such is not the case. Estimates show that the savings in miscellaneous accessory equipment required by the old system but not by the new, nearly offset the higher cost of the drive units and motor-generator sets of the new system.

A detailed analysis of the estimated costs is given in Table V of the complete paper.

Other Installations

This system of driving forced and induced draft fans is also being installed in two other power stations; *viz:* the Philo Power Station of the Ohio Power Company and the Sheboygan Power Station of the Wisconsin Power and Light Company.[2]

Another application of this system to the driving of power station auxiliaries differs radically from the ones previously described and illustrates the versatility of the system. It consists of a 2500-hp. drive unit geared to a reciprocating pump which delivers boiler feed water under a pressure of 1500 lb. per sq. in. This application calls for constant torque at

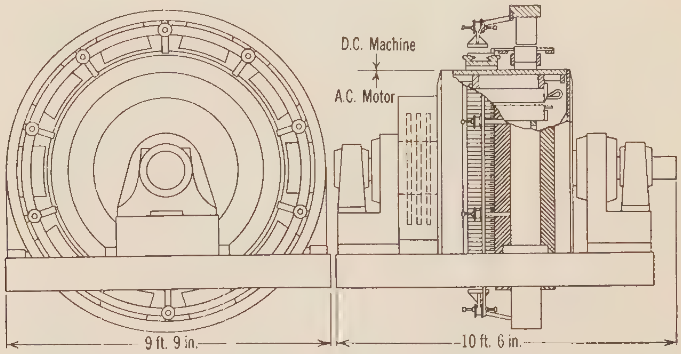

Fig. 11—2500-Hp. Drive Unit

adjustable speed. The design of the drive unit differs from the Powerton fan drive units in that the armature of the d-c. machine is assembled on the frame of the a-c. motor. The d-c. machine is thus concentric with the a-c. motor. The outline and dimensions of this drive unit are shown in Fig. 11. Two machines of this type are now under construction. The principal data pertaining to this application are given in the following table:

Max. shaft speed	708-rev. per min.
Min. shaft speed	282-rev. per min.
Range of shaft speed	100 to 40 per cent
Constant-speed component (a-c. power) at max. shaft speed	1750-hp. @ 495-rev. per min.
Adjustable speed component (d-c. power) at max. shaft speed	750-hp. @ 213-rev. per min.
Total power at max. shaft speed	2500-hp. @ 708-rev. per min.
Ratio of ratings—d-c. machine/a-c. motor	30/70
Rating of speed regulating motor-generator set for each drive unit	750-kw.
Over-all efficiency of drive unit and motor-generator set—	
At maximum speed	88.4 per cent
At middle speed	88.6 per cent
At minimum speed	78.3 per cent

The a-c. motors are designed for 2200 volts, three-phase.

Automatic Combustion Control

To take advantage of the simplified new system of fan control[2], a new and simple system of automatic combustion control has been developed.

Acknowledgment

The author wishes to acknowledge his indebtedness to Mr. R. B. Williamson of the Allis-Chalmers Manufacturing Company, for the interest he has shown in this system through the various stages of its development, and for the assistance he has rendered in bringing it to its present stage of development.

2. *Loc. cit.*

2. *Loc. cit.*

Recommendations on Balancing Transformer and Line Insulations On Basis of Impulse Voltage Strength*

BY V. M. MONTSINGER† and W. M. DANN‡
Fellow, A. I. E. E. Fellow, A. I. E. E.

Synopsis.—*The danger of over-insulating transmission lines without a corresponding increase in the insulation of connected apparatus is pointed out.*

To avoid trouble from lightning reaching the apparatus, the Transformer Subcommittee of the Electrical Machinery Committee has prepared a set of proposed rules covering: (1) A practical method of defining the impulse strength of transformers, and (2) recommendation on coordinating the transformer and adjacent line insulation on the basis of impulse voltage strength.

It is pointed out that commercial methods for determining the impulse strength of transformer windings by acceptance test in the factory are not feasible. However, investigations in the laboratory show that the impulse strengths of transformer insulation and of standard line insulators or of air-gaps vary similarly with different forms of waves; also that the impulse ratio of strings of line insulators of different lengths is approximately constant for the same impulse waves. The forms of impulse waves actually occurring on transmission lines have not been fully determined. For these reasons the impulse strength of transformers is expressed in terms of the 60-cycle dry flashover voltage of non-shielded suspension type insulators.

If the transformer and line insulation are properly balanced with a given wave, it eliminates the necessity of having to consider the different shapes of waves encountered in practise.

Three methods are recommended for coordinating the transformer and line insulation, namely, (1) the use of an effective lightning arrester; (2) the use of a horn-gap; and (3) the maintenance of average line insulation for a limited distance from the station.

* * * * *

General

For a great many years it has been the prevailing practise in the United States to correlate the amount of insulation used in a transformer and the value of the dielectric test which it receives with the voltage of the circuit on which the transformer operates. So long as the level of line insulation was kept at a reasonable value, this method worked out very satisfactorily.

Lightning has been the chief source of the abnormal transient voltages which on account of interruptions to service caused by line flashovers give serious concern to operating engineers. As a result, in an effort to remedy this condition, transmission engineers have been adding more and more insulation to their lines. The need for a more rational basis for insulating high-voltage transmission systems was pointed out by Philip Sporn in 1928.[1]

Where lightning is not severe, increasing the line insulation for normal service conditions has not resulted unsatisfactorily, but it is obvious that if the practise is continued without regard to the insulation of apparatus, trouble will result, as it has in some cases, because the maximum lightning voltage reaching the apparatus is limited only by the height and insulation of the adjacent lines and by protective devices, and is in no way related to the circuit voltage except in so far as the insulation of the circuit may change with the voltage.

The need of new insulation standards on account of this practise of increasing the line insulation has long been recognized by interested manufacturers and operators, and may now be said to be a necessity. Failure to adopt such standards has been due chiefly to lack of general recognition and acceptance of their proper governing factors, together with the difficulties of verifying them in the completed apparatus. Commercial methods for demonstrating the impulse strengths of transformers by acceptance tests in the factory are still not feasible. To make such a test on a transformer might cause undetected injury which would later result in failure in service; on the other hand, sufficient field experience and experimental data are now available by which it is possible to set up certain standards for the coordination of line and apparatus insulation.

Research and experimental investigations carried on by both manufacturers and operators within the past few years have yielded a great deal of new information relating to the impulse voltage strength of transformers, the impulse voltage arc-over of line insulators as determined by the laboratory, and to the magnitude and character of lightning voltages occurring on transmission lines as determined in the field.

Realizing the need of a more rational method of insulating high-voltage transformers the Transformer Subcommittee of the Electrical Machinery Committee in 1927 undertook the preparation of a set of recommendations for defining the impulse-voltage strength of transformers and for balancing the transformer with the adjacent line insulation.

While these recommendations have been completed

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1. For numbered references see Bibliography.

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and are used by the manufacturers for expressing the impulse strength of transformers, they have not yet been recognized by the Institute for coordination purposes.

Before attempting to get any action by the Institute, it was agreed that the Transformer Subcommittee and the Lightning Subcommittee of the Transmission Committee sponsor the symposium of papers being presented at this session. It is hoped that as a result of all these papers, a definite set of rules can be agreed upon which will be acceptable to all concerned.

The purpose of this paper is to give the recommendations prepared by the Transformer Subcommittee together with a discussion of some of the more important phases of the subject matter.

Proposed Rules

The proposal is divided into two distinct parts—Part I dealing with a method of defining the impulse strength of transformers, and Part II giving recommendations on coordinating the transformer and adjacent line insulation.

PART I

Impulse Voltage Strength of Transformer Insulation

(a)—Transformers Receiving Standard Dielectric Tests, as Specified in Par. 13-400, A. I. E. E. Standards No. 13.

Apparatus conforming with the standards of dielectric test should be so designed that their impulse strength against lightning is greater than the impulse flashover voltage to earth of non-shielded suspension type insulators having a 60-cycle r. m. s. dry flashover in accordance with Table I.*

TABLE I

Rated circuit voltage	Transformer 60-cycle test voltage	Insulator 60-cycle dry flashover voltage	Corresponding† No. of insulator disks spaced 5¾ in. apart
Kv.	Kv. r. m. s.	Kv. r. m. s.	
69	139	250	4
92	185	350	6
115	231	400	7
138	277	450	8
161	323	550	10
196	393	640	12
230	461	725	14
	510†	810†	16
	570†	895†	18
	625†	980†	20

(b)—Transformers Receiving Higher Than Standard Test.

If the 60-cycle dry flashover of the adjacent line insulation is greater than the value given in Table I, and is not locally limited to that value, transformers having a dielectric test corresponding to the actual adjacent line insulation should be used.

(c)—Transformers Receiving Lower Than Standard Test, as Specified in Par. 13-402 (n), A. I. E. E. Standards No. 13.

Transformers used with solidly earthed neutral and having the reduced insulation test of 2.73 times line to neutral voltage should have an impulse strength equal to that of a standard transformer for the next lower circuit voltage.

*Commercial methods for determining the impulse strength of transformer windings by acceptance test in the factory are not feasible. However, investigations in the laboratory show that the impulse strengths of transformer insulation and of standard line insulators or of air-gaps vary similarly with different forms of waves; also that the impulse ratio of strings of line insulators of different lengths is approximately constant for the same impulse waves. The forms of impulse waves actually occurring on transmission lines have not been fully determined. For these reasons, the impulse strength of transformer windings is expressed in terms of the 60-cycle dry flashover voltage of line insulators.

†These do not appear in the rules as proposed, but are given here merely for reference purposes.

PART II

Recommendations for Coordinating Transformer Insulation with Line Insulation in the Field

Limitation of lightning voltages, on the portion of the circuit adjacent to the apparatus, to the lightning flashover voltages of line insulation having the 60-cycle flashover voltages given in Table I may be accomplished by the use of one or more of the following methods:

Method No. 1.—An effective and properly applied lightning arrester connected to the circuit within 100 circuit feet (30 meters) of the terminals of the apparatus.

Method No. 1 furnishes the most effective protection, but in the absence of Standards for Lightning Arresters and their installation, Method Nos. 2 or 3 should always be used in combination with Method No. 1. If the impulse strength of the supporting insulation of the arrester conforms to the impulse strength of the gap with settings as given in Table II, then no additional parallel gap is necessary.

Method No. 2.—A suitable safety gap connected between each conductor of the circuit and earth within 100 circuit feet (30 meters) of the terminals of the apparatus with gap setting not in excess of the flashover voltage given in Table II.

TABLE II

Rated circuit voltage	Transformer—60-cycle test voltage	Gap—60-cycle dry flashover voltage
Kv. r. m. s.	Kv. r. m. s.	Kv. r. m. s.
69	139	185
92	185	240
115	231	300
138	277	355
161	323	410
196	393	500
230	461	585

These values apply to either arcing horns or rings attached to insulator strings or to points mounted separately. If rings are used, in order to avoid affecting the impulse ratio the gap should not be greater than 80 per cent of the length of the supporting insulator string.

Method No. 3.—Limitation of the line insulation to earth from points within 100 circuit feet (30 meters) of the terminals of the apparatus to points approximately ½ mi. (1 kilometer) therefrom, to values not in excess of the flashover voltage given in Table I.

Available Data on the Impulse Strength of Transformers

The available data on the impulse strength of transformers may be divided into two general classes, namely, those obtained in the laboratory and those obtained under service conditions.

The natures of the two classes of data are, of course, quite different because in the laboratory a transformer can be tested to destruction, while the data obtained under service conditions have been in the form of "records" covering many years of service. These records show that when connected to transmission lines having certain insulation, transformers receiving a certain dielectric test have successfully withstood lightning voltages. The conclusion is that the impulse voltage strength of the transformers is satisfactory when coupled with line insulation having a certain impulse

*Ratio of impulse to 60-cycle crest voltage arc-over.

arc-over voltage. For example, if transformers receiving a 60-cycle dielectric test of 231 kv. have been operating successfully for many years on a 115-kv. circuit exposed to severe lightning conditions, and the line is insulated with seven 10-in. (25.4-cm.) disks spaced 5¾ in. (14.6 cm.) apart, the flashover value of these line insulators may be used as a "yard stick," indicating the impulse voltage strength of the transformer. This, of course, does not give a numerical measurement of the impulse breakdown strength, but affords a convenient measure of satisfactory impulse strength.

Laboratory tests have proved to be of great benefit in determining the impulse arc-over voltage of insulator strings using various shapes of waves, in obtaining the impulse breakdown of insulating materials such as oil, solids, oil and solids in series as used in transformers, and of complete transformer windings. These tests have brought out the following points:

1. The impulse ratio* of various types of transformer windings is fairly constant for a given wave. The significance of this is that the low-frequency dielectric strength from windings to earth gives a rough measure of the impulse strength (from windings to earth).

2. The impulse ratio of the flashover of insulator strings of different lengths, and of point-gaps of various spacings in air is practically constant for a given wave.

3. The impulse strength of windings which are fully insulated in accordance with the A. I. E. E. Standards (*i. e.*, windings insulated for a test of twice line to line voltage plus 1000 volts) is satisfactory when used with average line insulation used in the United States.

Selection of Line Insulator Disks

Voltage arc-over values of 10-in. (25.4-cm.) insulator disks spaced 5¾ in. (14.6 cm.) between units, have been selected as the standard for expressing the impulse strength of transformers for circuit voltages of 69 kv. and above. Table I shows the general average number of 10-in. (25.4-cm.) disks used on the leading transmission lines in the United States[3] before the practise of over-insulating began.

Yard Stick Used to Express Impulse Voltage Strength of Transformers

Since the impulse voltage strength of transformers as herein defined bears a certain definite relation to the arc-over of standard suspension insulator disks when subjected to various shapes of waves, under both dry and wet atmospheric conditions, it is possible to express the impulse voltage strength of the transformers in terms of disks. It could be specified by definite numbers of disks but disks sometimes vary slightly in length of spacing. Since both the 60-cycle and impulse flashover voltage of insulator strings is, within reasonable limits of lengths, proportional to the total length of the string made up of disks having different spacings, it seemed that the most dependable way of specifying an insulator string that represents a definite measure of impulse voltage is by its 60-cycle arc-over value. It was decided, therefore, to use the 60-cycle *dry* flashover values for "yard-stick" purposes. This results in a very simple and convenient way of arriving at the desired results.

*Ratio of impulse to 60-cycle crest voltage breakdown.

The dry 60-cycle arc-over values of 4¾-in., 5⅛-in., 5¾-in., and 6½-in. spaced disks are given in Table III for reference purposes.

TABLE III

Unit No.	60-Cycle Dry Arc-Over Kv. r. m. s.			
	4¾ In.†	5⅛ In.	5¾ In.	6½ In.
1*	(78)	(78)	78	(78)
2	120	125	140	155
3	165	175	195	215
4	215	225	250	280
5	260	275	300	340
6	300	320	350	395
7	345	365	400	450
8	385	410	450	505
9	425	455	500	555
10	470	500	550	610
11	505	540	595	660
12	540	580	640	710
13	580	615	680	755
14	615	660	725	805
15	655	700	770	855
16	690	735	810	900
17	725	770	850	945
18	760	810	895	995
19	800	850	940	1040
20	835	890	980	1085

*Flashover of single unit taken as same for each size.
†Spacing between units.

The tabulation in Table I simply expresses the impulse strength of a standard transformer insulated in accordance with the American Institute Standards of Dielectric Test; it places no restriction whatever on the line insulation but rather it suggests suitable transformer insulation for any given adjacent line insulation. For instance, if it is desired to over-insulate the line next to the substation, Paragraph (b) indicates to what extent the transformers should be over-insulated. If, for example, a 230-kv. transformer is to operate on a circuit insulated with 18 instead of the standard number of fourteen 10-in. disks per string, the transformer should be given an insulation test of $461 \times \frac{895}{725} = 570$ kv.

On the other hand, if transformers of the reduced insulation class (built for operation with solidly and permanently grounded neutral and receiving an induced voltage test of 2.73 times line-to-neutral voltage) are used in accordance with the A. I. E. E. Standards, the adjacent line insulation should be reduced in the ratio of $\frac{2.73}{3.46}$. This reduction by coincidence corresponds approximately to the reduction in the adjacent line insulation for the next lower rated circuit voltage.

Recommendations for Balancing the Transformer and Transmission Line Insulation

So far, the method of expressing the impulse strength of transformers only has been discussed. It is quite important, however, that steps be taken by the purchaser to carry out the principle of balancing the transformer and the line insulation. If this is done, then the main part of the transmission line may be over-insulated without increasing the size and cost of the transformer.

Three methods are recommended: namely, (1) the use of an effective lightning arrester, (2) the use of a horn-gap, and (3) the maintenance of average line insulation for a limited distance from the station.

Method 1—Lightning Arresters

The requirement that Method (2) or (3) should always be used in combination with Method (1) is included because quite often the lightning arrester is temporarily disconnected for inspection, overhauling, maintenance, etc., and it is desirable to have something to act as a last line of defense.

Method 2—Horn-Gap

Quite often it is more convenient to use a gap to limit impulse voltages rather than maintaining average line insulation for a distance of one-half mile. This gap is sometimes in the form of spoons, or blunt points, mounted separately from the insulator string. Also, quite often the gap is formed by fastening guard-rings or arcing horns to each end of an insulator string using the insulators as a method of support. All these gaps as well as needle-gaps have practically the same 60-cycle and impulse arc-over characteristics for the same settings.

The gap impulse arc-over values are roughly 10 per cent less than the insulator impulse arc-over values. The reason for this is that except for a direct stroke of lightning at the transformer bank, the half-mile of reduced line insulation should provide better protection than a single gap having the same impulse voltage arc-over, because a wave coming in over the half-mile of normal line insulation will usually be attenuated more than 10 per cent by the time it reaches the station. By this is meant that if a wave comes along whose maximum value is just under the arc-over of the first insulator string, or if it arcs over the first insulation string, by the time it reaches the transformer one-half mile away, its maximum value has decreased at least 10 per cent below the value it had when passing the first insulator. Then, too, the one-half mile of normal line has several earthed points whereas a gap has only one. This should contribute to a little better protection.

It will be noted that the 60-cycle dry flashover values given in Table II are less than the 60-cycle dry flashover voltages of line insulators given in Table I by more than 10 per cent. This is because the impulse ratio of gaps is from 20 to 25 per cent greater than the impulse ratio of suspension insulator strings. Hence, for a gap to have say a 10 per cent less impulse arc-over the 60-cycle arc-over must be from 30 to 35 per cent less than that of an insulator string.

Method 3

The 60-cycle flashover voltage values given in Table I represent even numbers of disks spaced 5¾ in. (14.6 cm.) apart. Consequently, these voltage steps are not in all cases proportional to the circuit voltage steps. The 60-cycle values which correspond in steps to the circuit voltages ignoring whether or not they represent even numbers of disks, would be about as shown in Table IV.

TABLE IV

Rated circuit kv.	Trans. 60-cycle test voltage—kv. r. m. s.	Insulator 60-cycle dry flashover—kv. r. m. s.
69	139	250
92	185	315
115	231	385
138	277	450
161	323	520
196	393	625
230	461	725

The length of the insulator strings corresponding to these voltages would be as given in Table V.

TABLE V

Circuit kv.	Length of insulator string	
	Inches	cm.
69	23	57.5
92	31	78.8
115	39	99.0
138	46	117
161	55	140
196	68	173
230	80	203

From the above it will be noted that the length of the string in inches is roughly one-third the rated circuit voltage.

Where insulator disks have a spacing different from 5¾ in. (14.6 cm.), it is felt that values corresponding to the above, or as near as can be obtained with even numbers of disks, would be the more correct values to use rather than those given in Table I.

Nature of the Recommendations in Part II

These recommendations on balancing the transformer and line insulation are intended to be strictly advisory; they are given simply as a guide for the application of transformers on high-voltage transmission systems, considered from the standpoint of lightning voltages.

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Abridgment of

Synchronous Motor Effects in Induction Machines[1]

BY E. E. DREESE[2]

Synopsis.—*Many induction motors do not have the smooth speed—torque curves which are to be expected from elementary theory. Many motors at no-load show a tendency to run at some speed far below that normally to be expected. This is sometimes called "subsynchronous" speed; or the motor is said to be "crawling." In the present paper, one cause of this phenomenon is explained. It is found that certain combination of phases, rotor slots, and poles cause the motor to run as a synchronous motor at some intermediate speed between zero and normal no-load induction-motor speed. This effect has been christened the "synchronous-motor effect" in induction machines and is shown to be due to the locking of harmonic fields generated by the stator winding with similar harmonic fields generated by the rotor windings. A method is given for avoiding this trouble by the proper selection of the number of rotor slots.*

* * * * *

FROM time to time, those responsible for the design of induction motors are disappointed when a new design proves noisy or develops what is called a subsynchronous speed. The present paper will present a new cause for this phenomenon thus explaining some cases of subsynchronous speeds hitherto not understood.

The speed—torque characteristic of the classical induction motor is a smooth curve usually shown as in Fig. 1, but various investigators have found from time to time that seldom (if ever) is the actual curve as smooth as shown here. They find instead curves more like that shown in Fig. 2. Still more careful investigation reveals that the curves are actually very "rough" near zero speed, and Fig. 3 more nearly represents the true performance diagram.

FIG. 1—THE SPEED—TORQUE CURVE OF AN ORDINARY INDUCTION MOTOR AS USUALLY DRAWN

In all the above curves, the torque is shown as a single-valued function of the speed. This paper will show that in some cases the torque *is not* such a single-valued function and that none of the curves such as the above represents the true state of affairs.

The most plausible explanations advanced for these rough curves ascribe them to the presence of harmonics in the flux wave of the machine. As an example, consider a machine which has a prominent seventh harmonic in its flux wave; this harmonic if due to the stator winding will be revolving in the same direction as the fundamental, and at one-seventh of the fundamental speed in a three-phase motor. It is then illuminating to consider that the motor is really a composite of two motors which tend to run at full speed and at one-seventh speed respectively.

FIG. 2—THE SPEED—TORQUE CURVE SHOWING SUBSYNCHRONOUS "HOOK" DUE TO INDUCTION MOTOR EFFECT OF A HARMONIC

This is a plausible explanation of some of the subsynchronous speeds observed and might be shown as in Fig. 4. Without doubt, the presence of harmonics will produce such effects. This will also serve to explain the roughness of the curves in the lower speeds because of the presence of higher harmonics, which

1. This paper was submitted to the University of Michigan in partial fulfilment of the requirements for the E. E. Degree.

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effect will henceforth be called the "induction-motor effect" of the harmonics.

From this point, the development will be arranged chronologically as the calculations and experiments were made.

The work started on a squirrel-cage induction motor, wound for the three-phase four-pole operation and with 28-bar rotor. The motor showed a tendency to develop zero torque at one-seventh speed; therefore it was immediately concluded that this subsynchronous speed was due to the "induction-motor effect" of the seventh harmonic of the stator. Working with this in mind, the reasonableness of the assumption was tested by a mathematical check on the magnitude of the seventh harmonic in this particular motor, by the use of Fourier's methods. Since these methods are well known, they will not be reviewed here where results only will be stated.

The relative magnitudes as they actually existed in the stator m. m. f. were

fundamental	7th harmonic
1	0.01

As the result of this calculation it did not seem reasonable to "assume" that a seventh harmonic of 1/100 the magnitude of the fundamental and revolving at 1/7 the speed of the fundamental could produce enough

Fig. 3—Speed—Torque Curve Showing Roughness Usually Found in Lower Speeds Due to Higher Harmonics

torque by the induction-motor effect to overcome the torque of the fundamental at 1/7 speed.

Attention was then turned to the mathematical analysis of the rotor harmonics and after some false starts, the magnitude, order, and speed of the harmonics originating in the rotor were worked out.

Rotor Harmonics

Consider a squirrel-cage rotor of N bars being energized by a sinusoidal rotating field of p poles; it can then be seen that the actual rotor of N bars carrying currents of I magnitude $\frac{p\,\pi}{N}$ radians apart may be replaced by a rotor of N single-turn coils carrying currents of magnitude i and $\frac{p\,\pi}{N}$ radians apart provided,

$$I = 2\,i\sin\frac{p\,\pi}{2\,N}$$

Each coil produces backward and forward moving waves, since expressions of the type

$$\cos(m\,\theta - \omega\,t)$$

represent traveling waves of $2\,m$ poles.

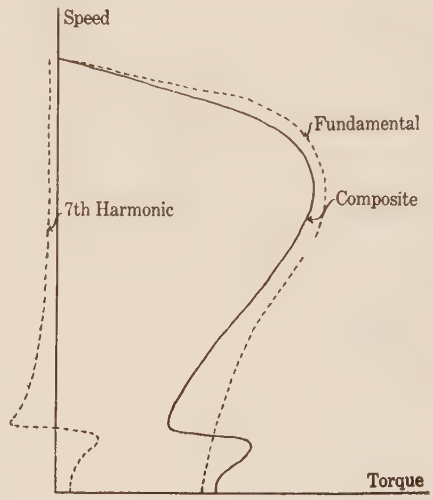

Fig. 4—Illustrating the Induction-Motor Effect of a Forward Rotating 7th Harmonic

Where K is any positive or negative integer including zero, forward rotating m. m. fs. of $2\,m$ poles are produced by the rotor if

$$2\,m - p = 2\,K\,N$$

and

$$2\,m = 2\,J\,N + p \qquad \textbf{(A)}$$

In like manner the backward rotating m. m. fs. form pencils whose adjacent fields are separated by

$$\frac{2\,\pi\,m}{N} + \frac{p\,\pi}{N}\text{ radians}$$

and in like manner, after the superposition, all those backward rotating fields vanish except those for which

$$2\,m = 2\,K\,N - p \qquad \textbf{(B)}$$

Synchronous Locking

Returning now to the consideration of the 28-slot rotor, a table was made showing the number of harmonic poles in both stator and rotor m. m. fs. In the above formulas (**A**) and (**B**), various values were substituted for p. These were the known fundamental and harmonic pole numbers of the stator m .m. f. In the present three-phase four-pole case, p may be 4, 20, 28,

44, 52, etc., for the fundamental fifth, seventh, eleventh, and thirteenth harmonics, respectively. Then, upon substituting various values for K, the several rotor harmonic pole numbers were found. These are shown in Table I.

TABLE I
28 SLOT ROTOR HARMONICS
Stator Poles P

4		20		28		44		52		68	
For.	Back.	For.	Back.	For.	Back.	For.	Back.	For.	Back.	For.	Back.
4	52	20	36	28	28	44	12	52	4	68	44
60	108	76	92	84	84	100	68	108	60	124	100
116	164	132	148	140	140	156	114	164	116	180	156
										12	

Soon after Table I was made up, it was noticed that the four-pole stator field, acting upon the 28-slot rotor, produced a 52-pole backward-moving rotor harmonic (the 13th). There was also present in the stator a forward rotating 13th harmonic of the 52 poles. The question naturally arose, how do these independently produced 52-pole fields react upon each other.

It was only a step to regard the 52-pole rotor field as the revolving field of a synchronous machine getting its

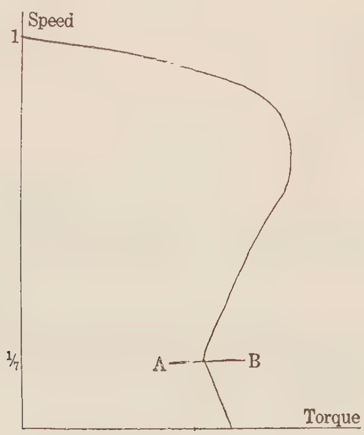

Fig. 5—Constant Speed—Torque Curve due to Synchronous Motor Effect

excitation from the stator fundamental flux instead of from a d-c. source.

The next natural step was to find at what rotor speed these 52-pole fields had zero relative speed; that is, at what rotor speed are the two 52-pole fields locked together.

Calculation shows that these two 13th harmonics lock at $\frac{1}{7}$ speed, which is the observed subsynchronous speed with the 28-slot four-pole rotor.

It was decided to take the speed—torque curve of the motor carefully on a dynamometer. This was as shown in Fig. 5.

Within the limits of accuracy of the tachometer, *there was* evidenced here a synchronous motor effect. Some representative points in the neighborhood of $\frac{1}{7}$ speed (257 rev. per min.) are shown in Fig. 6.

At 257 rev. per min. it appeared possible to vary the torque by 32 per cent without changing the speed.

With the stroboscope (Fig. 7) the flat portion of the speed—torque curve was observed to be *absolutely flat.* The motor was running as a synchronous motor super-

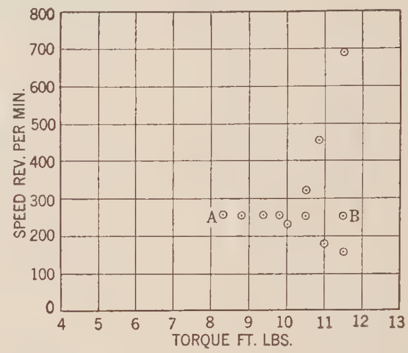

Fig. 6—Actual Test Points at Constant Speed due to Synchronous Motor Effect

imposed on an induction motor. As the load was varied, the only effect on the stationary image of the seven-point disk was that a slight shift in the coupling angle, as in a pure synchronous motor, was observed. As the torque approached points A or B in Fig. 5, the rotor showed hunting, vibrated erratically, and then dropped out of step, thereby definitely establishing proof of the existence of synchronous motor effect.

At this point, some definite experimental proof of the locking of the 13th harmonics was sought, and a

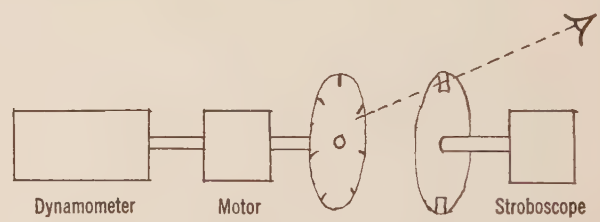

Fig. 7—Stroboscope Set-Up for Checking the Constancy of Speed in the Synchronous Motor Effect

check-up on the mathematical work showed that not only were the 13 harmonics locking but a *whole infinite series of harmonics was locking at $\frac{1}{7}$ speed.*

By calculation given in the complete paper it may be seen that there is an infinite series of locking pole numbers. The members of this series are 4 poles, 20 poles, 44 poles, 56 poles, 68 poles, etc., *and they all lock synchronously at $\frac{1}{7}$ speed.*

The discovery of the existence of an infinite series of synchronously locking harmonics caused a change in the point of view. Some conception of what is going on may be obtained by imagining an induction motor and an infinite number of synchronous motors connected to the same shaft.

All experiments conducted up to this point had been with the use of a skewed rotor. Various rotors with different skews were then tried and it was found that the length of the synchronous portion of the speed—torque curves was very sensitive to skew. (See $A - B$, Fig. 5). With a reduction in skew, the length $A - B$ increased until the point A crossed to the negative-torque side of the speed axis. Under this condition, the motor when started under its own power would

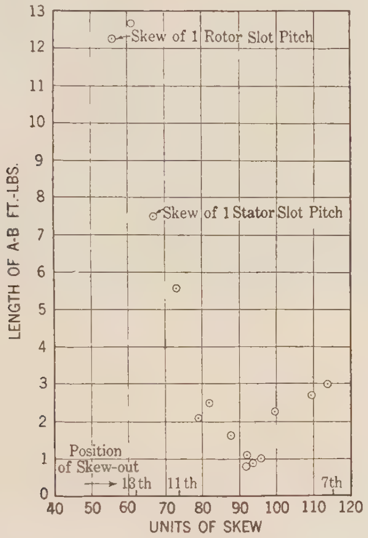

Fig. 7 —Showing the Effect of Skew on the Torque Length of the Constant-Speed Line

not come up to full speed but at the start would run at $\frac{1}{7}$ speed. It was therefore decided that a rotor built in such a way that the skew could be *varied* should definitely establish whether or not the synchronous motor effect was due to one pair of harmonics or to a plurality of pairs. This can be shown by a little consideration of the nature of skewing.

Effect of Skew

If a rotor were skewed through two complete pole pitches, there would be no voltage generated in the rod, and as a consequence, the rotor would act as though it had no winding for that particular pole pitch.

In an analogous manner, it is possible to "skew out" any particular harmonic by the single expedient of skewing the rotor rod through two (or any multiple of two) poles of that harmonic. The word "analogous" is used advisedly because it is at this point where another difference between induction motor effect and synchronous motor effect is shown.

So with the rotor with variable skew, it was only necessary to plot the length of the synchronous portion $A - B$ of the speed—torque against skew. If the synchronous motor effect were due to only one pair of harmonics, the length of $A - B$ must go to zero when that particular harmonic was skewed out. The results of this experiment (Fig. 7) show that no single harmonic is causing the synchronous torque. The minimum length for $A - B$ occurs between the points where the 11th and 7th harmonics are skewed out.

Designing to Avoid Synchronous Motor Effects

It remains to predict the synchronous motor effect for other motors. (See original paper). The following tables give the number of rotor bars per pole to be avoided in order to eliminate the synchronous motor effect.

VALUES OF $\frac{N}{P}$ WHICH GIVE SYNCHRONOUS MOTOR EFFECTS

TABLE II

L (columns); K (rows); entries $\frac{N}{P}$

K \ L	1	2	3	4	5
−1	4	7	10	13	16
−2	2	$3\frac{1}{2}$	5	$6\frac{1}{2}$	8
−3	$1\frac{1}{3}$	$2\frac{1}{3}$	$3\frac{1}{3}$	$4\frac{1}{3}$	$5\frac{1}{3}$
−4	1	$1\frac{3}{4}$	$2\frac{1}{2}$	$3\frac{1}{4}$	4
−5	$\frac{4}{5}$	$1\frac{2}{5}$	2	$2\frac{3}{5}$	$3\frac{1}{5}$

TABLE III

L (columns); K (rows); entries $\frac{N}{P}$

K \ L	−1	−2	−3	−4	−5
1	2	5	8	11	14
2	1	$2\frac{1}{2}$	4	$5\frac{1}{2}$	7
3	$\frac{2}{3}$	$1\frac{2}{3}$	$2\frac{2}{3}$	$3\frac{2}{3}$	$4\frac{2}{3}$
4	$\frac{1}{2}$	$1\frac{1}{4}$	2	$2\frac{3}{4}$	$3\frac{1}{2}$
5	$\frac{2}{5}$	1	$1\frac{3}{5}$	$2\frac{1}{5}$	$2\frac{4}{5}$

When a subsynchronous speed occurs, it takes place at a speed

$$\frac{n}{S} = -\frac{p}{K N}$$

Thus, all those values of $\frac{N}{P}$ in Table II give synchronous motor effects at positive speeds, and those in Table III give synchronous-motor effects at negative speeds.

Corresponding values of $\frac{N}{P}$ for two-phase motors are shown in Tables IV and V.

TABLE IV

L (columns); K (rows); entries $\frac{N}{P}$

K \ L	1	2	3	4	5
−1	3	5	7	9	11
−2	$1\frac{1}{2}$	$2\frac{1}{2}$	$3\frac{1}{2}$	$4\frac{1}{2}$	$5\frac{1}{2}$
−3	1	$1\frac{2}{3}$	$2\frac{1}{3}$	3	$3\frac{2}{3}$
−4	$\frac{3}{4}$	$1\frac{1}{4}$	$1\frac{3}{4}$	$2\frac{1}{4}$	$2\frac{3}{4}$
−5	$\frac{3}{5}$	1	$1\frac{2}{5}$	$1\frac{4}{5}$	$2\frac{1}{5}$

TABLE V

L (columns); K (rows); entries $\frac{N}{P}$

K \ L	−1	−2	−3	−4	−5
1	1	3	5	7	9
2	$\frac{1}{2}$	$1\frac{1}{2}$	$2\frac{1}{2}$	$3\frac{1}{2}$	$4\frac{1}{2}$
3	$\frac{1}{3}$	1	$1\frac{2}{3}$	$2\frac{1}{3}$	3
4	$\frac{1}{4}$	$\frac{3}{4}$	$1\frac{1}{4}$	$1\frac{3}{4}$	$2\frac{1}{4}$
5	$\frac{1}{5}$	$\frac{3}{5}$	1	$1\frac{2}{5}$	$1\frac{4}{5}$

It is seen that in the case of the two-phase motor, most synchronous motor effects occur at the same positive and negative speeds.

Initiation of an Electrification Into Operation

BY H. C. GRIFFITH[1]

Non-member

Synopsis.—This paper describes the energizing and putting into service of the Pennsylvania electrification project. The normal and desirable procedure of placing an electrification into service is cited, and the departure from it brought about by the difficulties encountered in actual railway operation are explained.

The operating practise—functions of the power director, his assistants, substation operators, and foremen in connection with switching operations, grounding circuits, carding of circuits and manner of obtaining releases—is described and illustrated. All of this is very essential to properly coordinate the work and safeguard the personnel of the construction forces, operating forces, and test men during the transition period of completion and placing into operation a railway electrification project.

* * * * *

The recent completion and placing in service of the Pennsylvania Railroad's electrifications between Philadelphia and Trenton, and Philadelphia and Norristown, has emphasized the importance to the railroad of the transition stage which turns a construction job into an operating job, and which has been called initiation into operation.

The normal and desirable procedure on an electrification construction job would be to complete the construction work with the construction forces, release the construction men, and turn the project over to a test organization who would then energize the various circuits and apparatus and make all necessary potential tests, check control operations, protective relay operations, automatic switching sequences, etc.

Unfortunately, a major electrification project which when completed becomes a part of an electrification system already in operation can seldom follow this logical sequence. The management who has authorized the large expenditure naturally want the operation to start at the very earliest possible date in order to obtain promptly the benefits for which the project was authorized. This necessitates the overlapping of the test period with the completion of the construction work, and results in having the construction forces working on portions of the circuits and apparatus while other portions are being energized and tested.

The situation is complicated further by the fact that the operating department requires a portion of newly electrified tracks turned over to them for a period before completion, for the operation of special electric trains for the training of crews. Also, if the project involves changing to a new transmission and distribution system for signal power, as was the case in the Trenton and Norristown electrifications, this supply of power must be available some time before completion of the construction work so that the signals and interlockings can be changed over prior to beginning of the operation. This results in having energized signal equipment, transmission, and trolley lines to contend with prior to the release of the construction forces.

To render as safe as possible for the construction force and others involved this transition period when work of construction on and around apparatus at times energized to a high potential for testing and training operations was necessary, a general plan was prepared and adopted.

The section being electrified was divided into three or four divisions, using points where the circuits were sectionalized as limits. The section which it was desired to energize first was taken as No. 1, the second as No. 2, etc. The construction work program was then so arranged that so far as possible No. 1 section would be pushed forward to completion—if needs be at the expense of the others; No. 2 would follow, and so on. This reduced to a minimum the amount of work the construction forces had left to do after the section in question had been energized, but did not entirely eliminate it, as test operation developed poor alinement of trolleys, hard spots in the catenary system, errors in substation wiring, and the need for readjustments in switches and circuit breakers.

A definite date and time was then set, after which all wires and apparatus in the first section should be considered energized to high potential at all times. The division superintendents were requested to issue a general order to be posted and signed for by the railroad employees, advising them of the exact time and the territory within which all overhead wires, substations and equipment must be considered energized.

A similar notice was forwarded to the superintendent of the construction forces, who was requested to have each man in his organization sign as having read and understood the notice.

The same thing was done for the field engineering and testing organization.

No voltage was applied to any of the equipment in each particular section until after the date and time specified in the notices applying to that section.

Prior to the date for energizing, various employees of the operating department were given a time allowance to go over in detail the new electrification project in order to become familiar with every phase of it. They were also given prints showing the arrangement and details of circuits. During this time allowance, they were expected to absorb sufficient information to enable them to pass a thorough examination to qualify in the particular class of work which they would be expected to perform when operation began; that is, the em-

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ployees who would operate as power directors were expected to learn thoroughly all phases of the project necessary to the transaction of business as power directors; the substation maintainers and inspectors to qualify along the line of their duties and the linemen along their special line. Each one was given a detailed examination by the supervisory force and was expected to pass this examination in a satisfactory manner.

A short time prior to the date and time specified in the

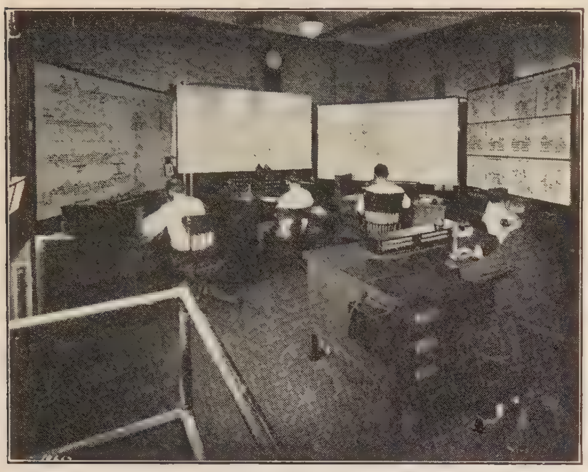


Fig. 1—Power Directors Headquarters at West Philadelphia Substation

General Notice issued, the power director was put on duty at the regular control headquarters to handle the energizing and testing of the new electrified section. A second and third trick power director were also

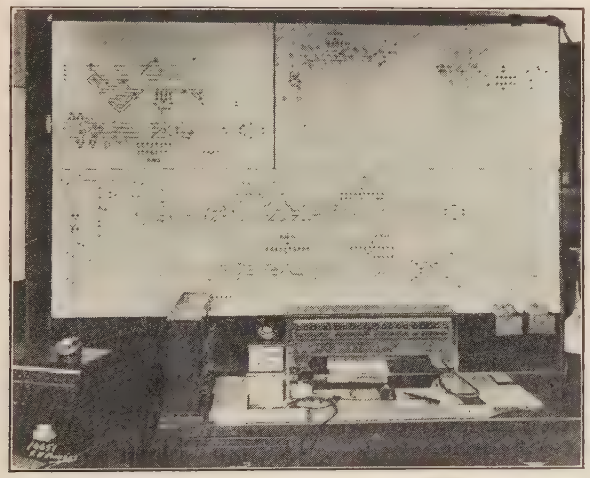


Fig. 2—Detail of Plug Board

Showing arrangements of trolleys and cross-overs with plugs at section-aligning and supply points

assigned so that for the full 24 hours each day, each move of energizing various circuits and apparatus and testing of same was done under the control of a properly qualified man.

Qualified substation operators were placed in each substation of the section, covered by the order to take out clearances and ground all high-voltage circuits or apparatus on which construction work remained to be done. The protection of the construction force in each particular substation was made the definite duty of these men, and in a number of cases it was necessary to supply qualified substation men for each of the three tricks in the 24 hours of the day.

In a similar manner a qualified lineman was assigned

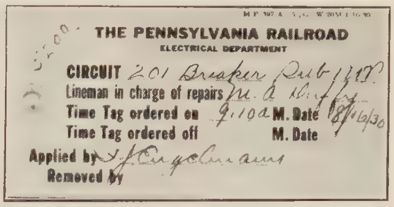

THE PENNSYLVANIA RAILROAD
ELECTRICAL DEPARTMENT
CIRCUIT 201 Breaker Sub 1 ...
Lineman in charge of repairs ...
Time Tag ordered on 9.10 A.M. Date 8/16/30
Time Tag ordered off M. Date
Applied by ...
Removed by

Fig. 3—Standard Clearance Tag to be Applied to Remote-Control Handle for Operating Switch

to each construction wire train, transmission gang, gang installing bridge protection, and each other gang whose duties involved its working over or around energized circuits. When necessary in order to permit construction work to be performed after portions of the electrification had been energized these qualified linemen would take out clearances and ground circuits for the performance of work by the construction gangs on or in close proximity to energized circuits.

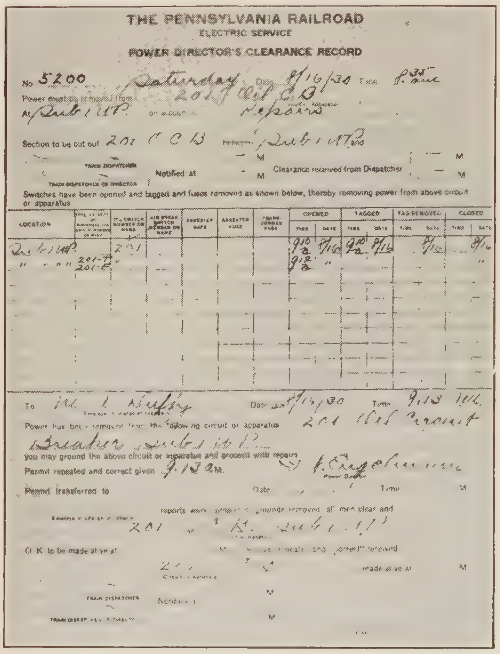

THE PENNSYLVANIA RAILROAD
ELECTRIC SERVICE
POWER DIRECTOR'S CLEARANCE RECORD
No. 5200 Saturday 8/16/30
Section to be cut out 201 ...
Notified at M. Clearance received from Dispatcher M.
Switches have been opened and tagged and fuses removed as shown below, thereby removing power from above circuit or apparatus
Permit repeated and correct given 9.13 A.M.
Permit transferred to
O.K. to be made alive at

Fig. 4—Clearance Record Prepared by Power Director for Each Clearance Issued

The power director referred to above is located in the West Philadelphia Substation and has complete jurisdiction over the operation of the electrical circuits and apparatus on the section of the electrification to which he is assigned. (Fig. 1). In case of faults developing on any portion of the system, it is his duty to restore power at the earliest possible moment. In case a fault continues, he so sectionalizes the system that

the portion of the system out of service is reduced to an absolute minimum. He must deal with the train dispatcher in the handling of trains in the electrified zone so that restrictions in train operation and the

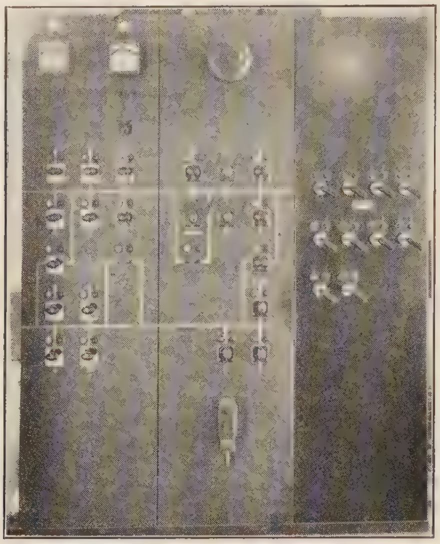
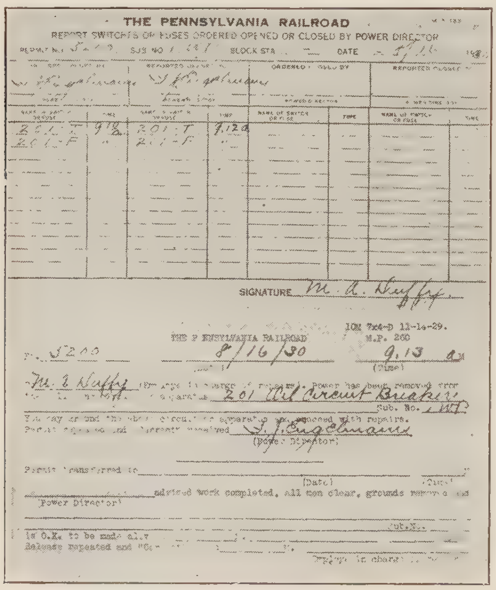


FIG. 5—CONTROL BOARD

Showing remote-control handle blocked out and clearance tag applied to three control handles

interruptions to train schedules are reduced to a minimum.

In case of a defective section of trolley developing, he must instruct the train dispatcher as to the condition


THE PENNSYLVANIA RAILROAD

REPORT SWITCHES OR FUSES ORDERED OPENED OR CLOSED BY POWER DIRECTOR

BLOCK STA DATE

SIGNATURE M. A. Duffy

THE PENNSYLVANIA RAILROAD M.P. 260

8/16/30 9.13

(Time)

M. E. Duffy

201 Oil Circuit Breaker

(Power Director)

advised work completed, all men clear, grounds removed

(Power Director)

FIG. 6—OPERATION REPORT FORM

Upper half—Standard switching blank filled out by operator

Lower half—Standard clearance blank filled out by qualified workman taking out clearance

existing in order to prevent the operation of trains into the defective section.

The responsibility for cutting out certain circuits or apparatus for normal maintenance is also a part of his duties. He selects the proper switches to be opened in order to remove power, and instructs the various operators usually located in the signal block towers, to open these switches and tag them prior to issuing the clearance to the qualified workman who performs the work. (Fig. 2.)

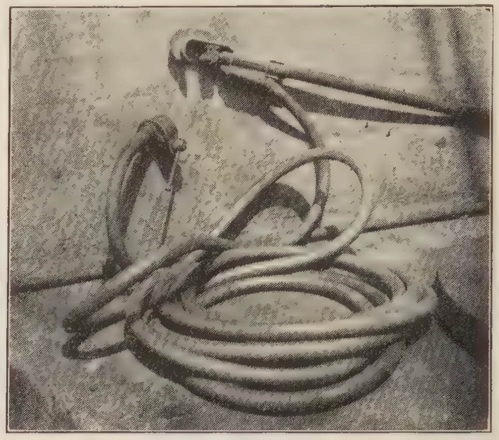


FIG. 7—STANDARD GROUNDING STICK

Showing clamp for conductor and clamp for ground connection

After the operator reports to the power director that proper switches have been opened and tagged with the name of the workman to perform the work as ordered by the power director, the power director then issues to the qualified employee in charge of doing the work a

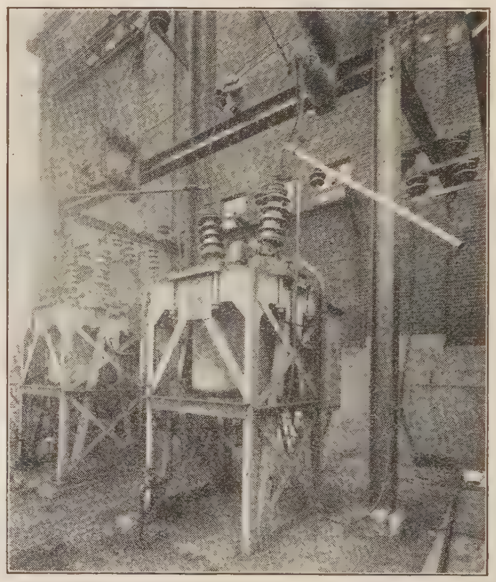


FIG. 8—GROUNDING STICKS APPLIED TO HIGH-SPEED TROLLEY CIRCUIT BREAKER

formal clearance. (Figs. 3 and 4.) The switches thus tagged must never be closed until the removal of these tags at the instruction of the power director has been accomplished.

Prior to the formal release of the clearance by the qualified employee to whom it has been issued the power director is forbidden to order closed any switches on which a clearance has been issued.

This rather elaborate formality has been found necessary to prevent the accidental closing of any switches energizing circuits on which men are working

and has proved to be an adequate safeguard. (Fig. 5.)

Where qualified substation operators and linemen are required to operate outlying disconnecting and sectionalizing switches not controlled from a remote control board, these operations must be performed only under definite instructions from the power director and a proper record kept on a switching report blank. The switching report blank and the clearance blank when completed must be forwarded at once to the operating headquarters for filing. The power director's record and the qualified employee's record of the clearance issued are checked and must be similar in all details. This checking is done periodically to prevent the development of carelessness on the part of any of the men involved in the handling of the clearances. (Fig. 6.)

After the qualified employee has received his clearance, before beginning work on energized equipment or circuits, he must apply the standard ground sticks which are supplied for that purpose. Upon completion of the work, these ground sticks must be removed before formally giving up the clearance under which he is working. (Fig. 7.)

The ground sticks are designed with a clamping hook on the end of a pole and an extremely heavy cable connecting to a clamp which clamps to a grounded connection or structure. Experience over a number of years has definitely proved that if these sticks are properly applied, the workmen will at all times be fully protected, not only from accidental energizing of circuits, but also in case of mistake in segregating the circuit or apparatus and the power not being removed. Ground sticks as illustrated in Fig. 8 have been applied to high-voltage circuits while energized without damage to the equipment or injury to the man involved.

The above general procedure has been reviewed in order to show the safety precautions found necessary in the handling of a major electrification project. It has been the experience that in spite of all precautions and safety features, accidents around high tension circuits will happen and every effort must be made at all times to keep those directly involved in their operation thoroughly familiar with these hazards and compel strict adherence to all safety regulations. There is no period to which this applies more strongly than it does to the period of initiating electrical operation and closing out the final details of the construction work.

Abridgment of

Phase Defect Angle of an Air Capacitor

BY W. B. KOUWENHOVEN*
Member, A. I. E. E.

and

C. L. LEMMON†
Non-member

Synopsis.—*This investigation was undertaken in order to determine the conditions of atmosphere under which the air capacitor may be regarded as having zero loss.*

A special guarded and shielded test capacitor was constructed having quartz insulation between the high-voltage and guard plates and low-loss molded Bakelite insulators between the measuring and guard plates. This capacitor was enclosed in a metal box and subjected to various conditions of temperature and humidity. Readings were made of continuous conduction current and a-c. phase defect angle. The measuring instruments used were the most sensitive available. A D'Arsonval galvanometer having a sensitivity of 1.5 $\times$ 10^{-12} amperes was used in the continuous current work and a Wien bridge sensitive to three seconds in the a-c. measurements. A gradient of approximately 4000 volts per cm. was used in all tests.

Measurements were made of the effect of humidity at temperatures from 60 deg. fahr. to 100 deg. fahr. and in each run the humidity was varied from approximately 40 to 95 per cent. Readings were made of continuous conduction current and the phase angle of the test capacitor was compared with that of a standard air capacitor in which the humidity was maintained at a low value. It was found that the conduction was zero and the phase defect angle of an air capacitor was less than three seconds for values of humidity below 90 per cent.

Observations were made also of the effect of the introduction of ions and dust particles into the condenser chamber.

* * * * *

Introduction

IMPROVEMENTS in impregnated-paper cable manufacture have necessitated many experiments in the measurement of phase angle. The a-c. bridge and the dynamometer wattmeter are the two methods commonly employed to measure dielectric loss. Both of these methods use air capacitors and the accuracy of the results is based upon the assumption that the air capacitors are loss-free; *i. e.*, the current leads the voltage by exactly 90 deg. The correctness of this assumption was questioned almost simultaneously by both the General Engineering Laboratory of the General Electric Company and by the Electrical Laboratory of the Johns Hopkins University,[1] during the summer of 1927. The trouble with the air capacitors developed during the summer months when the humidity was high. This investigation was undertaken to determine whether or not the known sources of atmospheric ionization were sufficient to account for the phase defect angle found, and to study the effects of humidity and temperature upon the behavior of air capacitors. The phase defect angle of a capacitor is the angle by which its current fails to lead the alternating voltage by 90 deg.

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1. For references see Bibliography.

Presented at the North Eastern District Meeting of the A. I. E. E., Springfield, Mass., May 7-10, 1930. Complete copy upon request.

Sources of Atmospheric Conduction

It is a well recognized fact that atmospheric air contains charged particles called ions, which will move when exposed to an electric field, thereby causing conduction.[2] The sources[3a] of ionization are radium emanations, soil gases, ultra violet light, cosmic rays, photoelectric effects, the Lenard[4] effect, whirling dust clouds,[5] and the products of combustion.

The normal ionizing agents produce from ten[6] to thirty[7] ions of each sign per cu. cm. per sec. These are removed by diffusion and recombination at such a rate that at any one time there are present per cu. cm. of the atmosphere from 700 to 1000 pairs[6] of ions.

The number not only varies at different localities, but also from hour to hour throughout the day. In cities the average number of small ions is 800 of both signs, per cu. cm., and of large ions 1800. The number of large ions present at any time depends mainly upon the amount of smoke in the air and may equal 60,000 or more per cu. cm. "Small ions[3c] consist of groups of some ten molecules, more or less grouped around a central charged molecule and forming a fairly stable complex or cluster." Large ions are small ions combined with dust or water particles, or both. The velocity of small ions is from one to two cm. per volt per cm. per sec., and the velocity of large ions from 1/100 to 1/1000 that of the small ions. The charge on an ion is usually taken as 1.59×10^{19} coulombs.

Atmospheric Conduction—Phase Defect Angle

If a capacitor is placed in still air, ions will not flow from the outside air into the capacitor and the number of ions available to cause conduction will be those generated per unit volume per second by the normal atmospheric ionizing agents. If these produce an average of 20 ions of each sign per cu. cm. per sec., and if none of these recombines the current per unit volume of the capacitor will equal 3.2×10^{-18} amperes.

Consider for example a high-voltage air capacitor having two measuring plates electrically connected, one on either side of a high-voltage plate, each plate being 121.9 cm. (4 ft.) by 182.9 cm. (6 ft.) At a spacing of 5.08 cm. (2 in.) the volume of air enclosed by the condenser is 227,000 cu. cm., and assuming that the voltage gradient is sufficient to draw out all of the ions formed, the conduction current amounts to 0.72×10^{-12} amperes. The electrostatic capacity of this capacitor equals 775 $\mu\mu$f. and at 60 cycles potential of 13,200 volts, the charging current is four milliamperes. The power factor of the capacitor under these conditions equals 1.8×10^{-8} and this is negligible.

If the air in the vicinity of the condenser contains 60,000 ions of both signs per cu. cm., and if we assume that the air currents are sufficient to completely change the air in the capacitor once every second, then the conduction current would equal 2.2×10^{-9} amperes, and the power factor, ($\cos \phi$), 0.55×10^{-6}. This corresponds to a phase defect angle of less than one second of arc and may be neglected.

It is evident therefore that the normal ionization of the atmosphere is not sufficient to account for the phase defect angles sometimes reported in air capacitors. Any phase defect that occurs must be the result of either leakage over the insulation, abnormal ionization caused by the flow of highly ionized air into the condenser space, or the presence of a dielectric other than air in the field.

Experimental Work

As stated before, the object of this investigation was to determine the effect of humidity, temperature, and ionization upon the dielectric, atmospheric air. Measurements were made of the conduction current flowing through an air capacitor under high continuous potentials and also of the power factor at corresponding values of 60-cycle voltages. A special test capacitor described below was constructed for this purpose.

The continuous current conduction was measured by a high sensitivity D'Arsonval galvanometer and as a check a-c. measurements were made in a Wien bridge, comparing the test capacitor with a standard capacitor. The effect of temperature was first studied in order to be sure that no thermal e. m. fs. existed in the test capacitor circuit. After proving that thermal e. m. fs. were absent, humidity runs were made, each at a definite temperature ranging from 21 deg. cent. (70 deg. fahr.) to 38 deg. cent. (100 deg. fahr.). In each one of these runs the relative humidity was varied from a low value to the highest attainable. No appreciable continuous conduction current was found and the d-c. and a-c. methods checked within the limits of accuracy of the equipment.

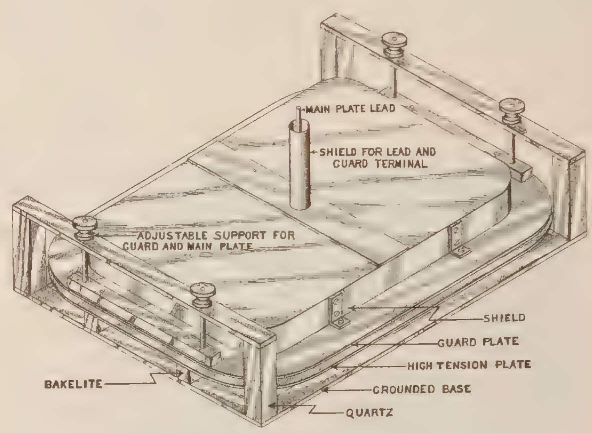


Fig. 1—Test Capacitor

The Test Capacitor

A flat plate capacitor (Fig. 1) was used as a test specimen, in which the atmospheric conditions could be varied. The high-voltage plate was 51 cm. (20 in.) × 38 cm. (15 in.), the guard ring 6.4 cm. (2.5 in.) wide, and the main or measuring plate 38 cm. (15 in.) × 25.4 cm. (10 in.). The width of the air-gap between guard

and main plates was 0.159 cm. (1/16 in.) and all plates were of 0.318 cm. (⅛ in.) brass. The plates were polished and all sharp edges removed. The main plate was suspended from the guard plate by Bakelite strips, running the full length of the condenser; brass studs, placed as near the center of these strips as was consistent with rigidity, held the main plate. The main plate was shielded by a brass case soldered and fastened mechanically to the guard ring. A brass tube concentric with the main plate lead was mounted on this shield and served both as the guard plate terminal and as a shield for the lead. The capacitance with 0.254 cm. (0.1 in.) spacing was 300 $\mu\mu$f. The capacitor was completely enclosed in a galvanized iron box. Outlets were provided for circulation of air and observation of conditions. An oil bath was used to control the temperature of the capacitor. The guard and high-voltage plates were both supported from a grounded base. All leakage over insulation from the high-voltage plate was led to ground and did not flow in the guard circuit. The guard ring was supported from the base by four quartz pillars. The best grades of low loss insulation available were used in the capacitor and care was taken to keep it out of the field. To reduce the chance of condensation to a minimum, the insulators were coated with a thin band of ozokerite wax.

The temperature of the capacitor was varied by means of an oil bath which heats only the bottom of the capacitor chamber. Heating of the bottom produced a small temperature gradient in the tank and circulating air currents resulted. These currents equalized the atmospheric conditions throughout the chamber.

The overhead suspension of the guard plate permitted variation of capacitance without in any way changing the leakage paths through the capacitor or the position of the insulating supports with respect to the field. The guard and measuring plates were hung from two horizontal supports by four brass screws and the spacing was varied by adjusting the length of the four supports by thumb nuts.

Continuous Current Measurements

A 1500-volt storage battery supplied current for the conductivity measurements. The high-voltage side of this battery was connected to the high-voltage plate of the test capacitor. The guard plate of the test capacitor and the other side of the battery were grounded. A high-sensitivity galvanometer was connected between the main plate of the capacitor and ground.

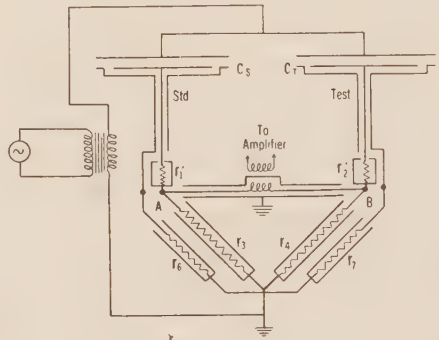
A-C. Measurement

The Schering and Wien or Rosa[9] bridges are most frequently used in high-voltage cable work. The Schering bridge has three condensers in the network and the Wien only two; therefore, since we were studying the effect of air conditions upon capacitance, we chose the Wien bridge to check the continuous current results. The diagram of connections is given in Fig. 3. This bridge compares the capacitances and the difference in the phase angles of the two capacitors, C_s and C_t, and does not therefore constitute a direct check upon the continuous current results. It was, however, the most sensitive method available, and by keeping the humidity and temperature in the standard capacitor C_s low and constant while varying that in the test capacitor C_t, we were able to detect any change in their relative phase defect angles.

Method of Varying the Humidity

Ions are not produced by slow evaporation from a water surface.[3d] Therefore trays holding water were placed in the box containing the test condenser and to increase the water surface, blotters were allowed to dip into the trays. There was a slight temperature gradient between the top and bottom of the box containing the capacitor, and this aided in circulating the air.

The relative humidity was measured by means of wet and dry bulb thermometers placed at the same level as the capacitor and close to the plates. Runs using this method of humidity control were necessarily long and each test extended over a period of twenty-four hours or more. This was not a disadvantage, however, as it gave sufficient time to obtain all of the desired data.



$C_T = C_S \frac{r_3}{r_4}$ $\quad$ $\tan \theta_1 = \omega C_S r_1'$

Fig. 3—Diagram Connections of A-C. Circuit

Operation

In this investigation, two sets of data—continuous current conduction and a-c. phase angle—were taken concurrently on the same air capacitor. A complete switching arrangement was installed, by means of which the capacitor could be transferred from one circuit to the other. Measurements were made at intervals consistent with the rate of change of the variable under observation.

In order to protect the high-sensitivity galvanometer from transients during the continuous current measurements, a definite cycle of operation was adopted. With the galvanometer short-circuited, the continuous voltage was applied to the capacitor circuit; after five minutes, the galvanometer was placed in circuit, a

reading taken, and it was again short-circuited. The circuit was then opened and the capacitor short-circuited for five minutes. Then with the galvanometer still short-circuited, voltage was applied in the opposite direction and after five minutes, the second or reversed reading was taken. The reversed readings made the accurate determination of the galvanometer zero unnecessary and also served to eliminate any contact potentials that might develop during a run. This method gave a very good check of conditions in the capacitor, and if the plates were free from dust or fibers, and the insulation free from moisture, the difference between the two readings was not greater than half a centimeter.

Three main operations were necessary in balancing the a-c. bridge: The first was to obtain an approximate balance of the main bridge at reduced galvanometer sensitivity. The second was to connect a second galvanometer (not shown in Fig. 3) between the guard and main plates of the standard capacitor and balance by adjusting the resistance r_6. The third step was to connect the second galvanometer between the guard and main plates of the test capacitor and to balance by adjusting resistance r_7. These three steps were repeated until the bridge was in balance for full sensitivity of the galvanometer and full amplification of the amplifier.

Each of the humidity runs was made at a definite temperature and the relative humidity raised slowly from the lowest value obtainable to as near one hundred per cent as possible. Before each run the condenser plates were carefully cleaned. The final cleaning operation consisted of scraping the plates with a safety razor blade to remove the last traces of lint and dust. The capacitor was then assembled and placed in its tank with calcium chloride dryer. After 24 hours the dryer was removed and measurements were made with both alternating and continuous current. If the value of the continuous current was negligible, it indicated that the capacitor was free from lint and dust. After securing a satisfactory set of readings with dry air, water was placed in the chamber with the condenser, the humidity increased gradually, and observations were made of both phase angle and conduction current.

Experimental Results

Four humidity runs were made, two at a temperature of 25.5 deg. cent., one at 31.7 deg. cent. and one 37.8 deg. cent. In each of these runs the relative humidity was raised from approximately 50 per cent to a value in excess of 90 per cent. The potential gradients used in the tests were of the order of 4000 to 5000 volts per cm. No continuous conduction current was found at values of relative humidity below 90 per cent. The a-c. bridge measurements checked the continuous current results. Above 90 per cent relative humidity erratic readings were obtained and these are believed to be due to condensation.

Conclusions

The following conclusions may be drawn from this investigation:

1. The normal ionization of the atmosphere is not sufficient to produce a measureable phase defect angle in a-c. measurements at commercial frequencies, involving an air capacitor as a standard.

2. The a-c. bridge observations indicate that any apparent phase defect angle in an air capacitor remains constant at values of relative humidity below 90 per cent.

3. The continuous conduction current in a properly shielded and guarded air capacitor in quiet atmosphere is negligible at values of humidity below 90 per cent. Therefore such a capacitor may be considered as an ideal capacitance.

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PULVERIZED FUEL

A revision of the American Standard "Safety Code for the Installation of Pulverized Fuel Systems" is announced by the American Standards Association. The rapid increase in the use of pulverized fuel in many industries, resulting in new developments in methods and design of equipment, is responsible for the revision. The original code was approved by the American Standards Association in 1927.

The code covers the construction of buildings housing fuel pulverizing equipment, the ventilation of these buildings, and specifications for dust collection systems. Specifications are given covering methods of preventing explosions through static, through the drying of coal, and through its transportation through pipe lines. The code also contains suggestions for safe operating rules to be printed on instruction cards which can be used for guidance of the employees in charge of the operation of such systems.

Miniature Switchboards

A Modernization in the Design of Operating Switchboards for Electric Power Stations and Substations

BY PHILIP SPORN[1]

Member, A. I. E. E.

Synopsis.—*This paper points out the general progress made in the design of electric power systems and contrasts with it the lack of progress in the field of control switchboards. It is shown that due to this lack of progress, a situation confronts many systems today where switchboards are so large that excessive amounts of space are necessary for their housing and further expenditures are later necessary in order to integrate these large switchboards so as to bring them within proper supervisory control of a limited number of operators. A development in miniature switchboards is described, embracing and containing all the fundamental requirements of a control switchboard and yet with no greater space than 4 in. of panel width for complete control and supervision of one feeder. A description of the instrument, control switches, and auxiliary relays, is given as well as the method in which all these elements have been assembled. Reproduction of drawings and photographs are given of actual installations along the lines described, showing the possibility of developing a switchboard that will handle 60 feeders and yet bring it within the range and operating control of a single operator, are given. The advantages of the new development are, as brought out: Compactness, ease of operation, closer supervision, ease of erection, good appearance, and modernity.*

* * * * *

I. Introduction

THE progress made in the design of central stations, substations and switching stations in the past two decades is too well known to those associated with the electric light and power industry to require any extended description. There has been tremendous improvement in the design of boilers, turbines, transformers and similar and related equipment, as well as development and extension of the maximum economic sizes, resulting in each case in larger, more compact units with decrease of the space required per kw. All this, although perhaps not apparent, is part of a general movement, a very pressing economic drive, to obtain a kilowatt of capacity for less investment. There can be no doubt that this is one of the most vital problems facing the electric power industry but unfortunately by the time it touches the switchboards its importance is very often lost sight of.

It is necessary only to examine switchboards of today and compare them with those of 10 or 20 years ago to be impressed with the truth of this situation. Today we find switchboards with perhaps better wiring or other refinements as compared with those which were built a decade ago, although substantially of the same type. To control an individual circuit or portion of the apparatus, there is generally employed a panel anywhere from 12 in. to 30 in. wide. It is true that this particular circuit may be handling more power than carried by a corresponding circuit 10 years ago, but this is exactly the sore point. The advance has been in the circuit itself; the switchboard design has not made a corresponding advance.

It is true that there have been some changes but in the main, there has been no fundamental progress. Thus we have seen the development of the back-to-back board which has cut down the over-all length necessary for the control of a given number of circuits. On the other hand, in many instances, the development of the idea of placing a bench board in front of the back-to-back board has resulted in requirements of greater cubage.

As a typical example of what this has led to, a case is cited of one of the most modern steam plants placed in service within the last month or so where a control room approximately 97 ft. by 30 ft. was provided for two 58,000-kw. units and one 15,000-kw. unit. After allowing for an ultimate layout of approximately 600,000-kw., the control room was found to be very definitely and uncomfortably crowded.

The general result from this lack of progress in switchboard design may be said to have been that the boards for the average station or substation have grown in size and reached a point where an ordinary operator or even a group of operators, cannot comfortably care for a single board. Or if they did take care of it, because of the size of the board, they would lack a proper view of the various parts of the system at all times, which in case of emergency or trouble when full knowledge is particularly essential, might prevent a proper carrying out of duties.

In consequence, we have seen developed the electrically operated dispatcher's boards, multiplying only the links in the chain. As a result of the sprawling design of the primary switchboard, we have come to a control board to integrate the primary board and to place the fundamentals in connection with its control in a sufficiently small space to be fully controlled by the operator in charge. That this has meant an economically wasteful development in two directions is apparent.

II. Modernizing Fundamentals

It was recognized that in order to get away from this

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cumbersome arrangement of switchboards, and provide a board on which all necessary instruments and control switches could be placed so that they would be entirely in view and under the hand of one operator, it would be necessary to develop a complete new line of small meters and small control equipment. Accordingly the problem was attacked from this angle and a great deal of work was done in the development of such

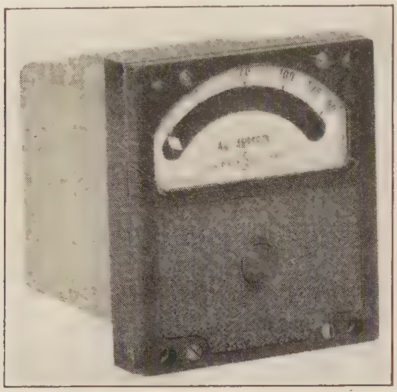

Fig. 1—A-c. Ammeter for Miniature Switchboard

meters, control switches, and indicating devices. This miniature equipment has been designed to be mounted on very small panels, and the resulting miniature board is capable of doing everything that could be done with the conventional and larger sized switchboard equipment.

Instrument elements have been developed for a-c. or d-c. ammeters, voltmeters, and wattmeters and kv-a. meters, which can be mounted in a standard case

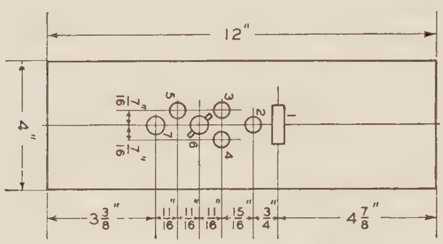

Fig. 2—Panel Showing

1. Card holder
2. Synchronizing receptacle
3. Green lamp
4. Red lamp
5. White lamp
6. Control switch
7. Operating key

having a front 4 in. wide by 4½ in. high and a body approximately 3½ in. square and from 6 to 10 in. deep. The scales on these meters are approximately 3½ in. long and are white with black markings. The needle pointer is furnished with a black tip. The front of this meter is drilled at each corner and supports the whole meter, thus allowing of direct mounting with four machine screws. The volt-ampere burden for these instrument elements is in general somewhat lower than for the standard instrument elements. Fig. 1 shows one of these instruments.

The control equipment and indications are taken care of by the use of a red light, a green light, and a white light, a control switch, a synchronizing receptacle, and an operating key or push button. The control switch itself is a development of the control switch used on supervisory equipments. The equipment is so wired that to close the circuit, the control switch is placed in the closed position thereby closing a contact which is in series with a contact of the synchronizing receptacle and the operating key. When the operating key is depressed, the closing circuit is energized. The tripping is taken care of by placing the control switch in the open position in which position its tripping contact is wired through the operating key so that when the key is depressed, the oil circuit breaker is tripped. Fig. 2 shows a panel on which this equipment is mounted and an elementary wiring diagram may be seen in Fig. 3.

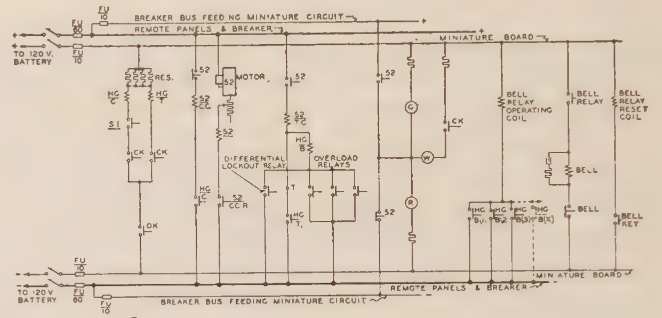

Fig. 3—Schematic Diagram for Typical Panel Showing Breaker Wiring

1. $\frac{H\ G}{C}$ Interposing closing relay
2. $\frac{H\ G}{T}$ Interposing tripping relay
3. $\frac{H\ G}{B}$ Series alarm relay in trip circuit
4. $S\ I$ Synchronizing receptacle
5. $C\ K$ Control switch
6. $O\ K$ Operating key
7. $C\ C\ R$ Control contactor
8. $T\ C$ Trip coil

However, in connection with this control switch, so far it has been necessary to use two interposing relays; one to handle the closing current, and one to handle the tripping current for the oil circuit breaker. A new control switch is being developed with adequate contact capacity so that the interposing relays will not be necessary. The interposing relay is a small instantaneous circuit-closing relay. The synchronizing receptacle consists of a telephone type jack and the wiring is shown in the elementary diagram of Fig. 3 and the arrangement of contacts as in Fig. 4.

III. Assembly

The development of these instruments, control switches, indicating lamps, and other devices has resulted in a new type of switchboard structure. This structure is fabricated from electrically welded steel plates. The two forms which have been developed, so far, consist in one case of an upright rectangular cabinet

fitted with a desk top extending from the panels at a height of about 30 in. from the floor, and in the other, of a number of individual sections which bolt together to form a polygonal arrangement with the switchboard

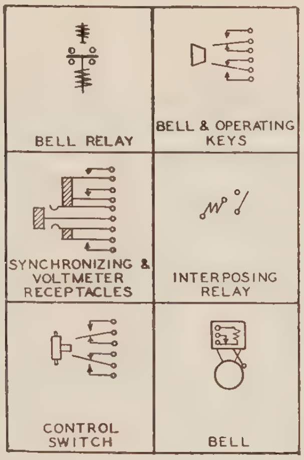

Fig. 4—Details of Switches and Relays

on the inner side, attached to which is a desk top similar to that for the other design. This latter type, providing for the development of the panels on a circle, makes it possible to assemble a number of panels in such a position that they can be more easily observed and controlled.

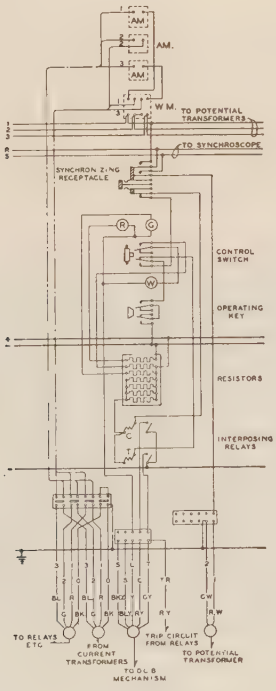

Fig. 5—Back View, Wiring Diagram of a Typical Feeder Panel

For both types of switchboard structure, the mounting is taken care of by cutting out sections from the steel fronts and providing frames to which the meters can be bolted directly. To this frame may also be bolted suitable small panels with the control switches, synchronizing receptacles, etc., mounted on them. A typical panel consists of the proper indicating instruments, control switch, indicating lamps, synchronizing receptacle, and operating key, etc., mounted vertically so that panel sections and meters are all flush. A wiring diagram is shown in Fig. 5 covering a typical panel. The arrangement may be seen from Figs. 6 and 7, which are the illustrations of two designs. Fig. 8 shows a plan view of a typical section for the polygonal arrangement, also a side and front elevation and Fig. 9 shows the method of grouping the sections.

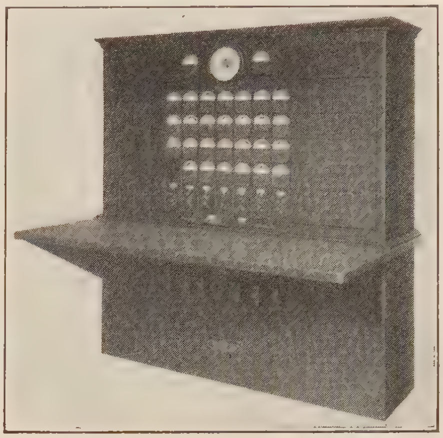

Fig. 6—Illustration of Rectangular Cabinet Type Switchboard

IV. Design Developments

Figs. 10 and 11 show two switchboards, Fig. 10 being a close-up view of the instrument and control section of an installation made at the Beaver Creek substation of the Kentucky and West Virginia Power Company and Fig. 11 a photograph of the board to be installed at the 132-kv. Zanesville substation of the Ohio Power Company, both of which companies are subsidiaries of the American Gas and Electric Company. From Fig. 11, which is a three-quarter view

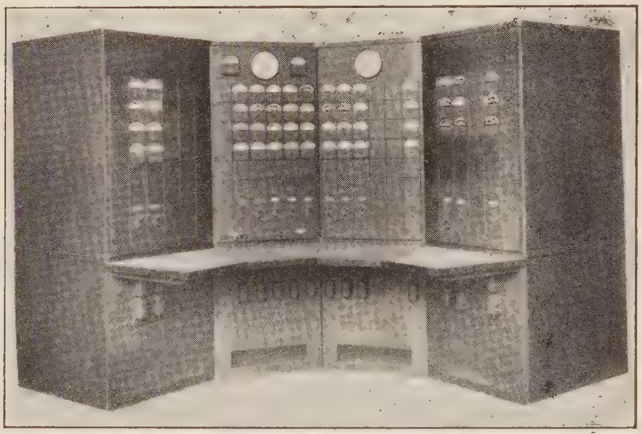

Fig. 7—Photograph of Multi-Unit Type Polygonally Arranged Switchboard

of the Zanesville board, it is evident how such a switchboard lends itself to complete supervision and ease of operation. From a swivel chair the operator can see all the instruments on the complete board and can easily reach all the control switches. The board shown in Fig. 11 consists of four sections totaling 24 circuits. As shown in Fig. 9, such a board can be expanded to 11 sections, and 66 circuits can be controlled just as readily.

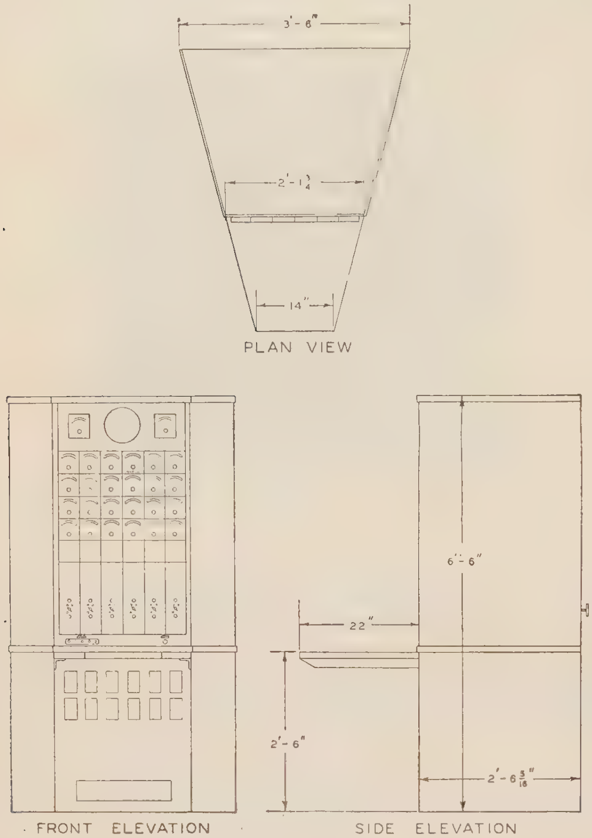

Fig. 8—Typical Unit for Zanesville 132-Kv. Substation Switchboard

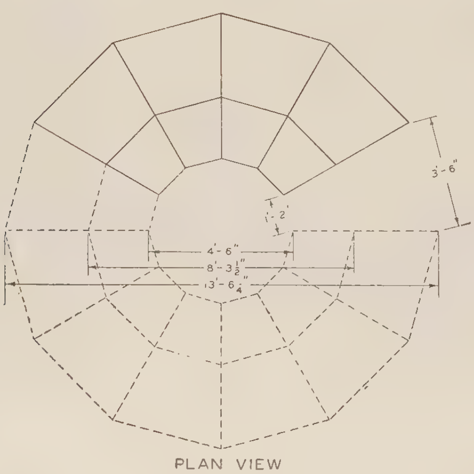

Fig. 9—Extent of Possible Development of Multi-Unit Board

V. Advantages

The advantages of the switchboard development described are almost self-apparent, but it may be well to summarize them here. They are:

1. Compactness. A board has been provided which takes up a small amount of space, certainly much less space than any other board heretofore developed attempting to accomplish the same functions.

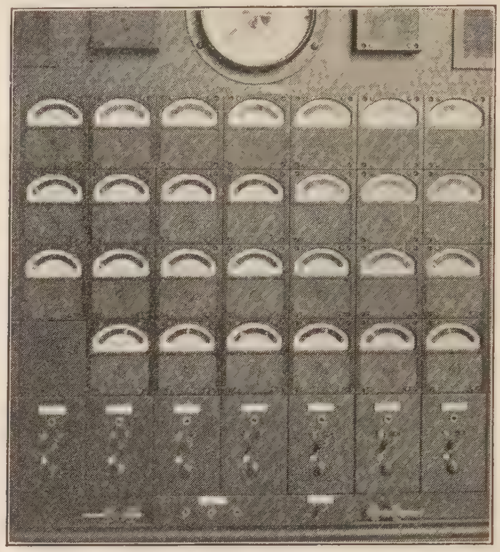

Fig. 10—Close Up View of the Instrument and Control Section of the Miniature Board Installed at Beaver Creek

2. Ease of Operation. As a natural concomitant, this compactness brings with it ease of operation. With no difficulty whatsoever a single operator can supervise the operation of 60 or more feeders and do so with a minimum amount of effort and a maximum amount of dispatch; further, due to the type of control switches employed, he can do this all while carrying on a telephone conversation or either giving or receiving instructions.

Fig. 11—Three Quarter View of Zanesville Switchboard Showing Ease with which It Can be Supervised

3. Closer Supervision. The small physical dimensions make it possible for the man actually operating the switchboard to exercise a closer degree of supervi-

sion; to know at a glance what has happened over the entire system supervised, and do so more easily than heretofore, without the intervention of other intermediate equipment. Besides, it saves the expense and complications of such additional equipment.

4. Ease of Erection. The board lends itself more readily than any other type of board to complete erection at the shop of the manufacturer and shipment complete as a unit. This makes for quicker installation and with less expense than when a board has to be disassembled before shipment.

5. Good Appearance. By no means a negligible point in the favor of the new development is its excellent appearance. It cannot be claimed that most of the boards that have been built within the past decade or so have had beauty of appearance as their strong point; the new board most decidedly is a great advance in that direction.

6. Modernization. The advantages may be summarized in brief, as follows: The board is a definite step in modernization of an item of station and substation equipment that has too long been left to accumulate tradition and that has too long followed along old beaten paths. It is believed that the step now taken will be helpful in the furthering progress toward the modernization of an important item in electric plant and substation operation.

Acknowledgment is due to the switchboard engineers of the General Electric Company, who obviously did all the instrument and most of the other development work, and particularly to Mr. Chester Lichtenberg, without whose sympathetic cooperation this development would have been impossible. The author also wishes to acknowledge the help he received from Messrs. H. E. Turner and R. C. Miller, in the preparation of this paper.

ILLUMINATION ITEMS

Submitted by the Committee on Production and Application of Light

STREET LIGHTING AT INTERSECTIONS

By W. T. Dempsey*

At the National Conference on Street and Highway Safety, in the report for 1929, statement is made that 33,600 people were killed and 1,200,000 were injured on the streets and highways of the country for that year. It was also found that more than 50 per cent of these accidents occurred at street or highway intersections, which are accordingly rated as the most hazardous part of the roadway. To reduce these figures, ever mounting year by year, the intersection should be attacked vigorously by all those interested in an effort to reduce the number of accidents occurring here. The respective number of accidents occurring in daylight and those occurring at night is unknown, but experience has shown that brightly lighted intersections will in a great measure reduce the hazard at night.

The diagram is drawn to indicate the possibility of accident at the intersection and at the 28 points where traffic intersects and which are therefore points of possible accidents. The vehicular movement being four-way, enters the intersection at points A, B, C, and D, following all the rules and regulations of the road, but without modern "Stop" and "Go" signals. Pedestrians are at liberty to cross in their allotted lanes. Assuming all follow the ideal lines of movement as indicated, the hazard to a single pedestrian is 2 or 6.66 per cent; a vehicle making a right turn 2 or 6.66 per cent; a vehicle passing straight across 6 or 20 per cent; a vehicle making a left turn 8 or 26.66 per cent; and a vehicle making a complete turn 12 or 40 per cent.

To reduce the hazard at night at points in the street or highway where traffic movements intersect, these

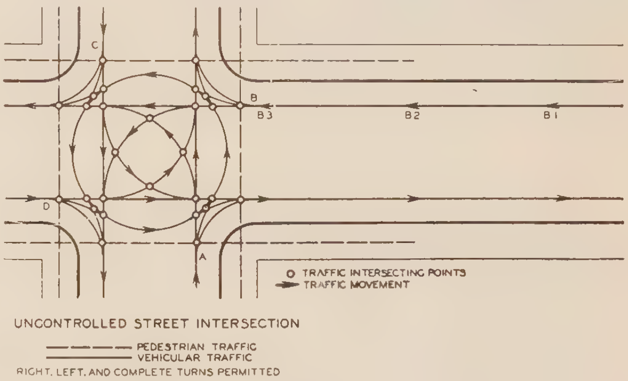

Fig. 1

points should be lighted at somewhat higher intensity in illumination than the lighting on the straight road. The following advantages will be gained: A pedestrian crossing at the intersection will be within the brightly lighted area; his vision will be keen, every object will be prominent, either by reflected light or by silhouette, depending upon the location of the light sources. An observer approaching the intersection on line B 1-2-3, being within an area of lower intensity in illumination, will distinguish objects ahead more by silhouette than by reflected light, and every object within or near the danger zone will stand out prominently. Even though there may be no object in or near the area, an observer approaching it at night will note the intensity of illumination, thereby marking it as a danger zone, and will approach it with caution.

Accident analyses have shown that proper street lighting has reduced accident frequency at night, and if study were made along the lines suggested, it appears that good results should follow. Where density of traffic warrants, a "Stop" and "Go" signal system would be of great help.

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The Southern District Meeting at Louisville, Kentucky

NOVEMBER 19-22

Interesting engineering developments, pleasant entertainment, addresses by eminent speakers and inspection trips to places of unusual historical and engineering interest are offered in the program of a four-day meeting of the Southern District to be held at Louisville, Kentucky, November 19-22. Headquarters will be at the Brown Hotel.

Engineering Papers

Descriptive engineering papers on steam and hydroelectric power generating stations in the Southern District, electrolysis conditions in Louisville, lightning, reactance-type relays, lighting airway beacons from high-voltage transmission lines, and reduction of transformer noise offer an insight into engineering practise in the South and are timely subjects of interest in the engineering field. Two papers on developments in design, single-phase series railway motors, and application of hydrogen cooling to turbine generators should prove of interest to the electric railway engineer and the central station engineer as well as the designer. Several papers leaning more toward the theoretical realm are to be presented in the session on protective devices. The complete list of papers, names of authors and the companies with which they are affiliated is given in the following part of this program.

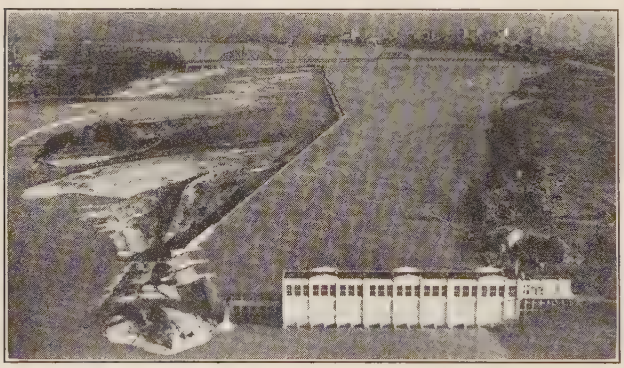
Student Activities

A student technical session will be held on Thursday morning, November 20th, at 10:00 a. m., when papers will be presented by the students. A conference on student activities will be held on Thursday afternoon.

Registration and Hotel Reservations

Members who plan to attend and have received the A. I. E. E. advance registration card should register in advance by filling out and mailing this card. Reservations for rooms should be made with the Brown Hotel direct.

Upon arrival at the meeting, members who have registered in advance should obtain their badge at the Registration Desk; those who have not registered in advance should also register promptly.



Power Plant and Dam of the Ohio Falls Hydroelectric Development at Louisville

Entertainment

An informal Smoker will be held on Wednesday evening at 8:00 o'clock. Mr. E. L. Manning of the General Electric Research Laboratories will give a demonstration and lecture on recent electrical developments in "The House of Magic."

On Thursday evening a Dinner-Dance will be held at 7:00 o'clock in the Brown Hotel.

Golf for those who care to play will be arranged for at 1:30 p. m. daily at the Audubon Country Club, Big Springs Country Club or Louisville Country Club.

OPENING SESSION

Wednesday, November 19

9:00 a. m. Registration.

10:00 a. m. Meeting called to order by General Chairman, J. P. Barnes.

Welcome by the Mayor of Louisville.

Professor Rodman, Presiding.

Remarks: Mr. W. S. Lee, *President*, A. I. E. E.

Mr. F. L. Hutchinson, *National Secretary*, A. I. E. E.

Professor Rodman, *Vice-President* of the Southern District, A. I. E. E.

TECHNICAL PROGRAM

Selected Subjects

10:30 a. m. *Electric Power in the Cement Industry*, R. H. Rogers, General Electric Co.

Electric Power in the Lumber Industry, A. H. Onstad, Weyerhaeuser Timber Company.

Automatic Arc Welding in the Electrical Industry, G. H. Koch, Westinghouse Electric & Mfg. Co.

A Cooperative Electrolysis Survey in Louisville, Ky., W. C. White, Southern Bell Telephone & Telegraph Co.

Transportation

2:00 p. m. Address: "Electric Railways," Mr. Charles Gordon, Managing Director, American Electric Railway Association.

Address: "Lackawanna Electrification," E. L. Moreland, Jackson & Moreland, Engineers.

Progress in the Design of Single-Phase Series Railway Motors, H. G. Jungk, Westinghouse E. & M. Co.

Thursday, November 20

10:00 a. m. Technical Student Session, D. C. Jackson, Jr., Presiding.

Transmission and Distribution

2:00 p. m. *Lightning Investigation at Aloca, Tenn.*, J. E. Housley, Knoxville Power Company.

Operating Experience with Reactance Type Distance Relays, E. E. George, The Tennessee Electric Power Co.

Trailer Mounted Substations for Emergency Use, F. L. Moser & H. B. Wolf, Duke Power Co.

Lighting Airway Beacons Direct from High Voltage Transmission Lines, F. W. Cartland, Westinghouse Elec. & Mfg. Co.

Friday, November 21

Protective Devices

10:00 a. m. *Grounded Neutral Y-Connected Potential Transformers on Ungrounded Systems*, C. T. Weller, General Electric Co.

Physical Nature of Neutral Instability, A. Boyajian & O. P. McCarty, General Electric Co.

Theory of Abnormal Line to Neutral Transformer Voltages, C. W. La Pierre, General Electric Co.

Protection of Three-Winding Power Transformers, R. E. Cordray, General Electric Co.

Power Transformer Noise—Its Characteristics and Reduction, R. B. George, Westinghouse Electric & Mfg. Co.

SELECTED SUBJECTS

2:00 p. m. *Governor Characteristics under Varying Load Conditions*, R. C. Buell, R. J. Coughery, E. M. Hunter, General Electric Co. and V. M. Marquis, American Gas & Electric Co.

The Ohio Falls Hydro-Electric Station at Louisville, Ky., R. M. Stanley, Byllesby Engineering & Management Corp. and E. D. Wood, Louisville Gas & Electric Co.

Modern Steam Stations of the Duke Power Company, M. E. Lake, Duke Power Co.

The Application of Hydrogen Cooling to Turbine Generators, M. D. Ross, Westinghouse Electric & Mfg. Co.

LADIES' ENTERTAINMENT PROGRAM

Wednesday

10:00 a. m. Welcome and announcements of activities.
3:00 p. m. Sightseeing tour of residential section of city and parks.
8:00 p. m. Ladies are invited to attend the informal Smoker and lecture.

Thursday

12:00 m. Bridge Luncheon at the Louisville Country Club.
7:00 p. m. Dinner Dance.

Friday

10:30 a. m. Shopping Tour of the business section of Louisville.
2:00 p. m. Matinee, Brown Theater.

Note: See "Inspection Trips" for a detailed description of tours of historical interest and scenic beauty.

INSPECTION TRIPS

Daily inspection trips will be made to the City Parks, the Ohio Falls Hydro-Electric Plant and the Water-Side Steam Plant of the Louisville Gas and Electric Company.

Arrangements have been made for inspection trips to the following points of scenic beauty and historical interest on Saturday. One of the following tours may be selected.

(TOUR "A") *Old Kentucky Home, St. Joseph's Cathedral—Bardstown, and Lincoln Shrine—Hodgensville.*

This is an eight-hour trip going via Dixie Highway to Camp Knox, Elizabethtown and returning via Hodgensville and Bardstown. A charge of $4.50 per person will be made to cover the cost of transportation, noonday country dinner and admission to Old Kentucky Home.

(TOUR "B") *Mammoth Cave.*

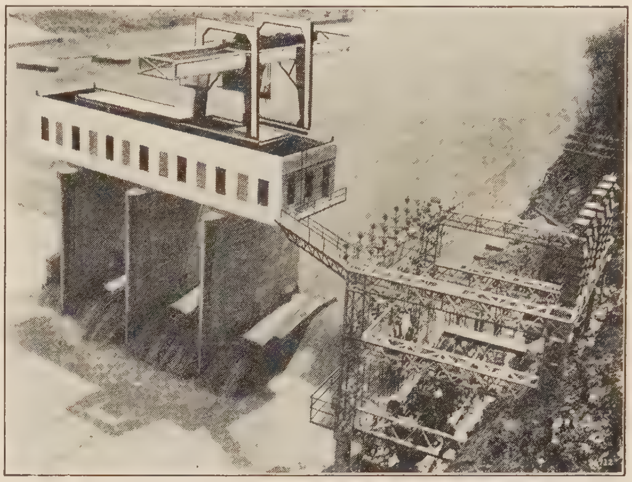
This is an eleven-hour trip, starting at 8:00 a. m. A charge of $7.50 per person will be made to cover the cost of transportation, noonday luncheon and admission to cave for three-hour trip.

(TOUR "C") *Kentucky River Tour.*

This is an eleven-hour trip which includes more points of historical interest and beauty than any other tour out of Louisville, passing through Shelbyville, Lawrenceburg, Harrodsburg, Dix River Dam, Shakertown, High Bridge, Versailles and Frankfort. Noonday luncheon provided at Graham Springs or Shakertown Inn and stops made at Old Fort Harrod, Herrington Lake, Dix River Dam and High Bridge. A charge of $6.00 per person will be made to cover the cost of transportation, noonday luncheon and admission to Old Fort Harrod.

COMMITTEES

The personnel of the General Meeting Committee consists of the following: W. S. Rodman, Vice-President, Southern District, No. 4, Honorary Chairman; James P. Barnes, Chairman; E. D. Wood, Vice-Chairman; A. S. Hoefflin, Secretary; Philip P. Ash, James Clark, Jr., G. W. Hubley, D. C. Jackson, Jr., F. H. Miller, L. S. Streng, Stanley Warth, H. W. Wischmeyer. The following are chairmen of the various subcommittees: F. H. Miller, Technical Program; Philip P. Ash, Hotels and Registration; H. W. Wischmeyer, Transportation and Inspection; Stanley Warth, Entertainment; D. C. Jackson, Jr., Student Activities; E. D. Wood, Attendance and Publicity; James Clark, Jr., Finance.



LOCK NO. 7, HYDROELECTRIC DEVELOPMENT ON KENTUCKY RIVER IN CENTRAL KENTUCKY

The Winter Convention

The annual Winter Convention will be held at New York in the Engineering Societies Building, January 26-30, 1931.

Plans are progressing for the selection of papers to comprise nine technical sessions on the following important subjects: Transportation; Symposium on Inductive Coordination; Communication; Transmission and Distribution; General Power Applications (Industrial Applications); Electrical Machinery; Electric Welding; Protective Devices and Research.

The papers which are to be presented in the Symposium on Inductive Coordination are each being prepared jointly by engineers engaged in telephone and power transmission work.

The keen interest being manifested at this time, together with the large number of papers under preparation and offered for presentation, should result in an unusual selection of a number of high-grade papers for the Winter Convention program.

Three-day Meeting at Philadelphia Ends With Outstanding Session on Railway Electrification

The Middle Eastern District of the A. I. E. E. held a three-day meeting at Philadelphia, October 13-15. Unusual opportunities for engineers to inspect recently completed railway electrification projects, substations and industrial manufacturing plants of electrical equipment and machinery were taken advantage of by a number of the members and their guests who attended the meeting. Total registration at the conclusion of the meeting was 500, which indicates the interest manifested.

The meeting was opened at 10:00 a. m.; William L. Thatcher made the address of welcome on behalf of the City of Philadelphia. The meeting was called to order by Mr. L. F. Deming, Vice-Chairman of the District Meeting Committee, President W. S. Lee and E. C. Stone, Vice-President of the Middle Eastern District, both making brief appropriate introductory remarks at this opening session.

Technical Sessions

The technical sessions were well attended and valuable pertinent discussions arose subsequent to the presentation of many of the papers. Twenty-two papers were presented in five technical sessions which constituted a very interesting program. The detailed summarized report of the discussions on these papers will be published in the December issue of the Journal. In accordance with the new practise regarding discussions, introduced at the Summer Convention at Toronto, discussions were not taken down by a reporter. Each discussor was requested to submit his remarks in writing prior to October 29th, 1930 in order that it might receive consideration for publication.

Railway Electrification and Electric Traction

The session on railway electrification and electric traction proved to be one of unusual interest.

Mr. C. L. Doub of Reading Company presented the first paper describing ultimate plans for the Reading Railroad electrification.

The second paper describing substations of the Broad Street Station of Philadelphia was presented by Mr. H. M. Van Gelder. The design of these substations with a view toward preventing noise disturbance to adjacent property indicates the high degree to which engineering details of design and construction are being carried out to protect public welfare. Mr. Van Gelder described the mercury arc rectifier installations, control apparatus and other electrical machinery contained within the stations. Provisions which were made for adequate ventilation and the methods of obtaining it were also stated in the paper.

Mr. A. H. Candee presented a paper on the internal combustion engine as an adjunct to electrification, advocating its economical use for yard switching in connection with electrified railways. Mr. Candee also cited the advantages of the combination electric locomotive capable of operating with current taken from the trolley and also equipped with the internal combustion engine for the source of power generation when the locomotive is used where the railroad is not electrified.

The fourth paper on the use of railroad rights of way for electric power transmission was presented by Mr. W. W. Woodruff. Special tower construction of towers spanning the railroad tracks and designed to accommodate the catenary construction and transmission circuits for railway electrification were illustrated by lantern slides. Lantern slides of special tower construction on the railroad right of way and adjacent to the tracks were shown and described by Mr. Woodruff. The ideas advanced in the paper have been put to practical application and mark an important epoch in the solution of certain right-of-way problems.

Mr. H. C. Griffith described the operating problem in connection with initiating an electrification into operation and outlined the Pennsylvania Railroad Company's solution of this problem in connection with its recent electrification. Control equipment, circuit hold-off cards, and other forms used in connection with switching operations were described and illustrated with the aid of lantern slides.

The last paper *Modern Single-Phase Motor for Railroad Electrification,* was presented by Mr. F. H. Pritchard. Mr. Pritchard described the recent refinements in design of the single-phase motor, which give it increased torque per pound weight of motor with satisfactory commutation.

During the discussion which ensued several prominent electrical engineers, including Mr. Sidney Withington, Mr. J. V. B. Duer and Mr. J. H. Davis, complimented the authors on the treatment of their subjects and expressed their views in turn. Several of the ideas advanced in the papers were questioned.

Other Noteworthy Papers

Mr. R. W. Wilbraham described and illustrated with the aid of lantern slides the design features and the construction problems encountered in connection with the 75-kv. submarine cable for the Deepwater Station. This installation is one of the outstanding cable installations completed during the past year. The cables used in connection with this installation are also the longest lengths of submarine cable of this particular size and capacity ever manufactured. Messrs. George A. Jessop, C. A. Powel, M. C. Olson, S. Logan Kerr and C. F. Wagner all presented very interesting and valuable papers on the subject of hydroelectric power generation. The ideas advanced in these papers cite the trend in recent developments, methods of economical control of operation, and design of damper windings for waterwheel generators.

Entertainment

The meeting Banquet was held on Tuesday evening. President W. S. Lee gave a very interesting address which completely and concisely stated the many activities in which engineers are engaged at the present time.

Entertainment in the form of singing and classical dancing, with music by White's orchestra, was provided by the Entertainment Committee. The Banquet was well attended by by many of the members and their guests and dancing was enjoyed until midnight.

Summary of Pacific Coast Convention Discussions

Only discussion which was given at the meeting and submitted in writing to the A. I. E. E. Editorial Department, 33 West 39th Street, New York, N. Y., prior to September 19, and in accordance with A. I. E. E. rules on discussion, is summarized in the following columns. Other discussion submitted in accordance with A. I. E. E. rules on written discussion, but communicated after adjournment is not reported here but will be published in the Transactions also.

A complete list of the papers presented was published in the August issue of the Journal.

Session on Transmission

Mr. J. T. Lusignan, Jr., in discussing the paper *Wood Arms on Steel Structures* emphasized an advantage in Mr. Austin's design in which wood arms are used where direct-hit wires are mounted on steel towers and grounded through their structures. He cited that Mr. Bewley pointed out the need for low footing resistances because the voltage between conductor and tower increases with increased footing resistances. Therefore, when wood arms are used the conductor-to-tower insulation is greatly increased and tower footing resistances may be appreciably higher than is permissible when only ordinary suspension string insulation is present.

Mr. H. L. Melvin's discussion on the use of wood for insulation was read by Mr. E. A. Pearson. Mr. H. L. Melvin believes that Mr. Austin's paper is another contribution of useful data on the possible utilization of the impulse insulation of wood for increasing line insulation strengths to lightning voltages. The need of actual operating data was cited and the use of protecting horns of suitable design was advocated to prevent shattering of wood arms on steel structures.

Discussion by Mr. J. T. Lusignan, Jr. of Mr. Bewley's paper was read at the meeting. Mr. Bewley's work was highly complimented as representing a thorough contribution to or knowledge of ground wire theory. It pointed out clearly the relations between different methods used in the past for calculated and measured values of protection afforded by ground wires against lightning induced surges, and this permitted present practise to use the older data with more assurance.

Mr. J. E. Clem's discussion of Mr. Bewley's paper points out that separations in the order of 35 ft. between the line wires and the direct hit wire may not be necessary because operating experience obtained during the year just closing indicates that a large number of outages are caused by direct hits. The second point brought out by Mr. J. E. Clem was that the use of additional ground wires adjacent to the station cannot be justified on the basis of voltage reduction occurring in traveling waves

when passing the junction. Mathematical proof, formulas, and tables of calculations, are submitted in an appendix to substantiate this conclusion.

Mr. A. O. Austin complimented Mr. L. V. Bewley upon giving a very fine mathematical treatment of ground wire theory and expressed hope that Mr. Bewley would continue his analysis for other conditions. Many points were cited in Mr. Austin's discussion, and one point in particular was stressed: In determining attenuation Mr. Austin emphasized that the size of conductor and ground wire together with the polarity of the transient be given consideration.

Mr. L. V. Bewley read Mr. H. L. Rorden's discussion on the influence of polarity on high-voltage discharges. Oscillograms were submitted illustrating sparkover differences due to polarity using various electrodes and different wave forms.

Mr. George S. Smith in his discussion on the influence of polarity in high-voltage discharges described tests which he had conducted. Characteristic impulse voltage—time curves for standard 15-kv. pin type insulators under standard dry and rain conditions were illustrated with the aid of lantern slides. The negative impulse was applied first to the cap and then to the pin, and the crest kilovolt values to arc over the insulator were found to be less for all values of time after arc-over took place when the negative impulse was applied to the pin of the insulator.

Afternoon Session on Transmission

In discussion on the *Mechanical Performance of Oil Circuit Breakers*, Mr. A. O. Austin asked a question about the present status of opening time. Mr. A. C. Schwager replied that time requirements of 12 and 8 cycles are common and the ultimate goal is one-half cycle. The fact that damping forces are stated to be negligible was questioned by Mr. Bewley. Mr. Schwager replied stating that all the torque transmitting parts move at very low velocity; only the blades rotate at high speed and a very small cross-section is exposed. New investigations will have to be carried out with a decrease in opening times to values of one-half cycle.

Mr. L. V. Bewley in his discussion of the paper on *Corona Loss Measurements on a 220-Kv., 60-Cycle, Three-Phase Experimental Line*, cited that corona losses are responsible for rapid attenuation and distortion of high-potential traveling waves. The law of corona has not been established for traveling waves; therefore, from the point of view of transmission system protection it would seem advisable for experimenters to give attention to transient corona loss.

Mr. A. O. Austin discussed corona loss from the standpoint of radio disturbance. Tests to determine relative radio interference using conductors of different diameter and design were submitted. Oscillograms show that the disturbance is due to a discharge on the positive wave. Mr. Austin points out the possibility that some method may be devised which will make it possible to determine the corona loss by a radio interference method as a means of supplementing work similar to that carried out in the Ryan Laboratory.

Mr. R. S. Daniels cited an interesting example of apparent change in corona after a 130-kv. line was put into operation. Serious radio trouble was noted at first but this decreased in about three months' time and could not be accounted for other than that it was due to a decrease in corona which took place in the meantime.

Mr. Ellis Van Atta asked Professor Carroll for an explanation of the fact that corona losses were increased due to rain and that they remained high after the conductors had dried off.

Mr. K. A. Hawley's paper on *Development of the Porcelain Insulator* was presented by title only. Mr. A. O. Austin contributed valuable discussion pertaining to certain points in this paper.

Session on Power Stations

Mr. L. V. Bewley discussed Messrs. F. J. Vogel's and J. K. Hodnette's paper. In his discussion Mr. Bewley showed mathematically to what extent, in his opinion, the author's test circuit fails to duplicate the functioning of an actual line.

Mr. K. K. Palueff's discussion on *Grounding Banks of Transformers with Neutral Impedances* was read by Mr. Bewley. Mr. Palueff believes that, fundamentally, he and Messrs. Vogel and Hodnette are in agreement and that it is just a matter of further tests on their part to bring their experimental results into complete accord, as are their theoretical conceptions of the phenomena.

Mr. A. W. Copley discussed the steps in the development of grounded systems and various methods used to limit the ground fault current. He cited that Messrs. Hodnette's and Vogel's paper gives very valuable evidence as to what takes place under these surge conditions.

Session on Communication

In connection with the discussion on *Commercial Aircraft Radiophone Communication*, Mr. F. B. Doolittle described conditions encountered and tests conducted when assisting a large air transport company to clear up some radio interference.

A discussion by P. F. Scofield on *Harmonic Generation by Means of Grid Circuit Distortion* was read by Mr. T. H. Morgan. Mr. P. F. Scofield described results of tests made on the harmonic generator at frequencies above 3,000,000 cycles, using tubes having ratings up to 250 watts. The grid distortion principle was found to be operative at fundamental frequencies above 3000 kilocycles. A reasonable amount of power was obtained on 8 meters with a generator driven by an 80-meter crystal.

Mr. E. L. White discussed the serjdetour described in the paper by Messrs. Ashbrook and F. B. Doolittle. Mr. White believes the device is more than adequate for the duty it has to perform. He described a modified standard horn-gap and its accessory equipment used by his company for protection.

Session on Research and Development

In discussion of the paper by J. V. B. Duer on *The Pennsylvania Railroad Electrification*, Mr. T. A. Purton inquired about what special measures were taken to prevent telephone and communication interference. Mr. H. T. Plumb added to this question the matter of radio interference.

Mr. A. F. Gorton discussed the paper on *An Electric China Firing Kiln* and inquired about its commercial possibilities. Mr. Gorton pointed out that electric firing has been employed lately in the annealing of telephone receiver magnets and other metallurgical products requiring close temperature regulation.

NATIONAL RESEARCH COUNCIL

THIRD ANNUAL MEETING OF COMMITTEE ON ELECTRICAL INSULATION NOVEMBER 7 AND 8, 1930

Opening on Friday Nov. 7 with an address of welcome by Doctor G. K. Burgess, Director of the Bureau, there will be an interesting session of the Committee on Electrical Insulation, Division of Engineering and Industrial Research, at the Bureau of Standards November 7th and 8th. The report of Doctor J. B. Whitehead, Chairman of the Committee will next be presented, reports of various subcommittees and personal theses on live subjects to follow in the order here given.

Program

Friday, November 7

Welcome by Doctor G. K. Burgess, Director, Bureau of Standards.

Report of Chairman, Doctor J. B. Whitehead, Johns Hopkins University.

Technical Session—Subcommittees on Physics and Chemistry: *Subcommittee on Physics*, Professor V. Karapetoff, Cornell University; Chairman. *Studies of Molecular Motions in Dielectrics under Electric Stress*, by Doctor R. D. Bennett, University

of Chicago; *The Electric Moment of Tung Oil*, by Professor A. A. Bless, University of Florida; *The Short-Time Characteristics of Insulating Oils*, by Professor J. B. Whitehead, Johns Hopkins University; *The Nature of the Conductivity of Insulating Oils*, by Professor K. F. Herzfeld, Johns Hopkins University; *Report of Subcommittee on Chemistry*, by Mr. F. M. Clark, General Electric Company, Chairman; *The Electric Properties of Organic Compounds*, by Mr. S. O. Morgan, Bell Telephone Laboratories; *The Conductivity of Liquid Hydro-carbons*, by Doctor G. W. Gardiner, Bureau of Standards; *The Electric Properties of Rubber*, by Doctor A. H. Scott, Bureau of Standards.

The program will continue in the afternoon with a technical session including *The Variation of Dielectric Constant with Temperature and with Frequency*, by Professor A. A. Bless, University of Florida; *Effect of Superposed High Frequencies on Insulation*, by C. F. Hill, Westinghouse Electric & Mfg. Company; *The Electrical Characteristics of Insulating Oils*, by Dr. H. H. Race, General Electric Company, and a lecture on "Dielectric Constant and Dielectric Loss, Recent Theory and Experiment," by Professor J. W. Williams, University of Wisconsin.

Saturday morning November 8, further technical session will be held with the presentation of papers on *The Predetermination of the Deterioration of Impregnated Paper Insulation*, by D. W. Roper, Commonwealth Edison Company; *Behavior of Hydrocarbons and of Paper under Electric Discharge*, by Mr. C. F. Hirshfeld, Detroit Edison Company; *Cable Research at the University of Illinois*, by Professor E. B. Paine, University of Illinois; *Insulation Research at the Massachusetts Institute of Technology*, by Professor V. Bush, M. I. T.; *Ionized Gas Films in Solid Dielectrics*, by Professor C. L. Dawes, Harvard University; *The Life of Impregnated Paper Insulation*, by Professor J. B. Whitehead, Johns Hopkins University and *Analysis of Loss in Impregnated Paper*, by Professor W. B. Kouwenhoven, Johns Hopkins University.

It is fair to assume that this will be an occasion for the dissemination of much valuable engineering data.

Alfred Noble Prize Now Open

One of the most valuable types of recognition of the attainment of young engineers was instituted in 1929 in the Alfred Noble Prize, an award from the income of a fund contributed by engineers and others in honor of Alfred Noble, Past-President of the American Society of Civil Engineers, and of the Western Society of Engineers. Named after one of the most illustrious and best beloved members of the profession in the history of American engineering, its particular purpose is to perpetuate his name and achievements.

Recipients of the award may be members in any grade of one of the four National Societies of Civil, Mining, Mechanical and Electrical Engineers, or of the Western Society of Engineers. The basis of selection will be the content of a technical paper of particular merit accepted by any of these societies for publication, in whole or in abstract. However, provision is made that at the time of the paper's acceptance, the author may not be more than 30 years of age. This, in effect, limits it to the younger engineer, a particularly significant fact as related to Alfred Noble's life.

Specifically, the prize consists of the sum of $500 in cash, together with a certificate suitably engraved. With it goes a letter bearing a statement of the outstanding facts relating to the life and works of Alfred Noble; this is signed by the President of the American Society of Civil Engineers, serving as trustee of the fund.

Selection for this prize is detailed to a committee of five, one from each of the constituent societies. The winning technical paper must have been presented in the publications of one of the societies within the twelve months preceding July 15 of any year; thus it behooves any young authors to submit papers meriting consideration in ample time. To provide for the delays of examination and approval for publication, manuscript might well be sent immediately, insuring eligibility for the prize covering the year ending July 15, 1931.

The More Recent Developments of the Bell Telephone Laboratories

TO BE DESCRIBED TO THE NEW YORK SECTION

On the evenings of Tuesday and Wednesday, November 19 and 20, 1930 the New York Section of the Institute will hold a joint meeting with the New York Electrical Society and the Museums of the Peaceful Arts. On each of the two evenings there will be a lecture and demonstration entitled "Play-o-fine Crinkanope" by Sergius P. Grace, Assistant Vice-President, Bell Telephone Laboratories, Inc. Many of those who have previously had the pleasure of listening to Mr. Grace will recognize in the cryptic title to this lecture the hint that he will again demonstrate the scrambled speech apparatus. Other demonstrations will include the electric brain, delayed speech, electro-stethoscope, hearing without sound, the dial that speaks and many others. The lecture, which will review the most recent developments of the Bell Telephone Laboratories, will be presented by Mr. Grace in the usual simple but dramatic manner.

In order to insure accommodations for all, the meeting will be held at Mecca Temple, 133 West 55th St., New York, N. Y. Admission will be by ticket only. Reservation forms will shortly be mailed to all Section members. Tickets will be obtainable from F. M. Delano, Secretary, New York Electrical Society, 29 West 39th St., New York, N. Y.

STANDARDS

Revision of "Recommended Practise for Electrical Apparatus on Shipboard" Approved

At the October 9th meeting of the Standards Committee there was received a report constituting a revision of "Recommended Practise for Electrical Installations on Shipboard," Section 45 of the A. I. E. E. Standard series. This revision, while extensive as to material affected, involves no fundamental changes, simply revisions due to changes in practise and development of the art. It was prepared by the A. I. E. E. Technical Committee on Application to Marine Work under the chairmanship of R. A. Beekman of the General Electric Company. These Recommendations, originally called the "Marine Rules," appeared in their first edition in 1920 and in revised form in an edition of 1927, which the present revision will supercede. The Standards Committee approved the revision as submitted to them and on their recommendation, the Board of Directors acted likewise on October 15, 1930. The work of issuing a new edition will begin at once.

Standards for Switchboards and Switching Equipment for Power and Light Approved

Under date of October 15, 1930 the Board of Directors of the Institute approved as an A. I. E. E. Standard, No. 27, "Standards for Switchboards and Switching Equipment for Power and Light." The final approved standard is a revision of Report No. 27, which has been in circulation since June 1929. It was developed by a subcommittee of the Standards Committee before which the report came on October 9th. The Standard will be issued shortly in pamphlet form by the Institute.

Standards for Insulator Tests Approved as American Standard

On September 19, 1930 the "Standards for Insulator Tests" were approved by the American Standards Association as an American Standard. This standard is a revision of A. I. E. E. Standard No. 41 of July 1925. The revision was developed by a Sectional Committee working according to the procedure of the

A. S. A. and under the joint sponsorship of the Institute and the National Electrical Manufacturers Association. The revised edition of No. 41 will be available at a cost of 30 cents to non-members of the A. I. E. E., a 50 per cent discount to apply for members of the Institute. Address communications to Secretary, Standards Committee, A. I. E. E., 33 West 39th St., New York, N. Y.

Navigational and Topographical Symbols Approved as American Standard

On July 17, 1930 the "Standard for Navigational and Topographical Symbols" was approved by the American Standards Association as American Tentative Standard. The Institute as one of the five joint sponsors for Sectional Committee on Scientific and Engineering Symbols and Abbreviations, through which the Standard came, had already placed its approval on the standard. Definite arrangements on the final publication of this standard have not as yet been made.

Symbols for Photometry and Illumination Approved as American Standard

On August 4, 1930 the "Symbols for Photometry and Illumination" developed by the Sectional Committee on Scientific and Engineering Symbols and Abbreviations were approved by the American Standards Association as an American Standard. The standard has been published in pamphlet form by The American Society of Mechanical Engineers, 29 West 39th St., New York, N. Y., from which copies may be obtained at a cost of 20 cents each.

Revision of American Standard "Code for Lighting Factories, Mills, and Other Work Places"

Following approval by the Illuminating Engineering Society, the American Standards Association has approved a revised American Standard, "Code for Lighting Factories, Mills, and other Work Places." The code, which applies to practically all industries, is intended as a guide for factory owners and operators in their efforts to improve lighting conditions, and also as a source of authoritative information for bodies preparing safety regulations. Copies of the code may be obtained through the American Standards Association, 29 West 39th St., New York, N. Y. at 20 cents per copy.

Revised National Standard for Dry Cells and Batteries

A Sectional Committee under the sponsorship of the U. S. Bureau of Standards, and organized under the procedure of the American Standards Association has developed a revised national standard for dry cells and batteries. This has been approved by the American Standards Association. The standard sets up specifications for materials, workmanship, performance, sizes, and markings and covers dry cells and batteries for radio, telephone, ignition, flashlight, and other uses. A part of the standard is devoted to methods of test which will determine compliance with the specifications. This standard will be published by the Bureau of Standards and become available through the Superintendent of Documents, Washington, D. C.

Lehigh Dedicates New Packard Laboratory

Lehigh University, Bethlehem, Pa., officially accepted a cherished gift when it dedicated the James Ward Packard Laboratory of Mechanical and Electrical Engineering with appropriate ceremonies October 15-17, 1930. In conjunction with the dedication there was held an all-day conference concerning the "Relations Between the Industries and the Technical Schools" and a half-day conference on the "Future of American Industry." Alumni from far and near, together with representatives of various major industries and delegates from other institutions and associations, participated in and contributed to inspirational discussions looking to the furtherance of scientific education as it is needed to meet present-day needs.

The laboratory itself was designed by the Lehigh faculty and built at a cost of $1,200,000, all of which together with an endowment for operation was presented by the late James Ward Packard, founder of the Packard Electric Company and the Packard Motor Car Company. As a memorial the laboratory is singularly appropriate because the donor distinguished himself in both mechanical engineering, with his leadership in motor car design, and in electrical engineering, with his participation in early electrical developments. As a laboratory, it stands as the realization of Lehigh's dream, for it provides facilities not only for the present student body, but makes adequate provision for sometime into the future.

The building is approximately 124 by 170 ft. in plan and the equivalent of five stories in height. The main laboratory space is 63 by 124 ft. in plan and includes two main floors of these dimensions with a spacious balcony encircling the upper floor to accommodate the lighter equipment. The balance of the building is given over to class rooms, small individual research rooms, instrument rooms, offices, and accommodation rooms for the convenience of students. In addition, there is an auditorium on the lower floor which seats 600 persons with comfort. Careful attention was given to such details as ventilation, lighting, and soundproofing.

Although there is no physical division within the building, the total space is equally divided between the mechanical and electrical departments. Each department devotes approximately 60 per cent of its floor space to laboratory and research work, 30 per cent to class rooms and offices, and 10 per cent to coat rooms, study rooms, and lounging conveniences for the students. In the main lobby stands the first Packard automobile, donated by that company in appreciation of the sentiment of the late Mr. Packard. The building and its equipment are under the supervision of Professor Fred V. Larkin, head of the M. E. department, and Professor Stanley S. Seyfert, acting head of the E. E. department.

Doctor Charles M. Schwab, chairman of the board, Bethlehem Steel Corporation and Past-President of the American Society of Mechanical Engineers delivered the dedicatory address. He sought to impress his audience with the vital necessity of closely coordinated efforts on the part of both industry and the technical school in the interest of developing men of sufficiently broad training to meet the increasing demands of industrial and sociological development.

Others who addressed the conferences included F. A. Merrick, President of the Westinghouse Electric & Manufacturing Company; Wm. Butterworth, President of the U. S. Chamber of Commerce; L. W. Baldwin, President of the Missouri Pacific Railway; A. G. Glancy, President of the Oakland Motor Car Company; M. S. Sloan, President of the Brooklyn Edison Company; Bancroft Gherardi, Vice-President and Chief Engineer of the American Telephone & Telegraph Company; Dr. A. M. Greene, Dean of the school of engineering, Princeton University; Dr. D. C. Jackson, head of the Department of Electrical Engineering, Massachusetts Institute of Technology; David Ross, President of the Board of Trustees of Purdue University; Dr. W. E. Wickenden, President, Case School of Applied Science; M. A. Alexander, President, National Industrial Conference Board; E. A. Filene, President and Chairman of the board of Wm. A. Filene's Sons' Company (Boston); Dr. John Johnston, Director of Research, U. S. Steel Corporation; and S. L. Andrew, Chief Statistician, American Telephone & Telegraph Company.

A. I. E. E. Directors Meeting

The regular meeting of the Board of Directors of the American Institute of Electrical Engineers was held at the Benjamin Franklin Hotel, Philadelphia, on Wednesday, October 15, 1930, during the Philadelphia District Meeting of the Institute.

There were present: President W. S. Lee, Charlotte, N. C.—Past-Presidents R. F. Schuchardt, Chicago, Ill.; Harold B.

Smith, Worcester, Mass.—Vice-Presidents W. S. Rodman, University, Va.; C. E. Sisson, Toronto, Ont.; G. C. Shaad, Lawrence, Kans.; I. E. Moultrop, Boston, Mass.; T. N. Lacy, Detroit, Mich.—Directors A. B. Cooper, Toronto, Ont.; F. C. Hanker, East Pittsburgh, Pa.; J. E. Kearns, Chicago, Ill.; A. E. Knowlton, New York, N. Y.; E. B. Meyer, Newark, N. J.; C. E. Stephens, New York, N. Y.—National Secretary F. L. Hutchinson, New York, N. Y. Present by invitation: H. A. Kidder, Chairman, Committee on the Engineering Profession, New York, N. Y.; H. H. Henline, Assistant National Secretary, New York, N. Y.

A report of a meeting of the Board of Examiners held September 24, 1930, was presented and the actions taken at that meeting were approved. Upon the recommendation of the Board of Examiners, the following actions were taken upon pending applications: 179 Students were enrolled; 67 applicants were elected to the grade of Associate, seven to the grade of Member, and one to the grade of Fellow; 50 applicants were transferred to the grade of Member, and eight were transferred to the grade of Fellow.

The Board ratified the action of the Finance Committee in approving, for payment, monthly bills amounting to $32,319.65 for the month of September, and $35,370.87 for the month of October. A budget for the appropriation year beginning October 1, 1930, submitted by the Finance Committee, was adopted.

Secretary Hutchinson reported 986 members (902 Associates, 80 Members, and four Fellows) in arrears for dues for the fiscal year which ended April 30, 1930, and was authorized to remove from the membership list on December 1, 1930, all those whose dues for that year remain unpaid and who have not indicated a desire to continue membership, requesting an extension of time for the payment of the dues.

Upon the request of the Section and District officers of the Pacific Coast, approval was given to holding the 1931 Pacific Coast Convention at Lake Tahoe, Calif., August 25-28.

Mr. F. W. Peek was elected a Director of the Institute to fill the vacancy in the Board of Directors for the term ending July 31, 1933, caused by the election, last spring, of W. S. Lee to the presidency of the Institute.

Upon the recommendation of the Standards Committee, the Board voted to approve a revision, made by the Committee on Applications to Marine Work, of A. I. E. E. Standard No. 45, "Recommended Practise for Electrical Installations on Shipboard," and to approve for adoption as A. I. E. E. Standard, Standards on Switchboards and Switching Equipment for Power and Light, prepared by a working committee of the Standards Committee.

Complying with the provisions of the constitution and by-laws, five members of the Board were selected to serve on the National Nominating Committee, as follows: H. P. Charlesworth, A. B. Cooper, E. B. Meyer, Harold B. Smith, and C. E. Stephens.

A revision of the pamphlet, "Suggested By-laws for Sections," was approved for printing and distribution to Section and District officers.

The following Institute representatives were appointed to serve on the U. S. National Committee of the International Electrotechnical Commission for the term following the Plenary Session of the I. E. C. in Oslo, July 1930: L. F. Adams, E. W. Allen, James Burke, W. A. Del Mar, Gano Dunn, F. C. Hanker, C. R. Harte, H. M. Hobart, D. C. Jackson, F. B. Jewett, A. E. Kennelly, C. O. Mailloux, Wm. McClellan, J. F. Meyer, H. S. Osborne, Farley Osgood, F. W. Peek, Harold Pender, L. T. Robinson, D. W. Roper, C. H. Sharp, C. E. Skinner, W. I. Slichter, N. W. Storer, and J. W. Upp. In addition, the Institute has the following representatives, *ex-officio*: W. S. Lee, President, A. I. E. E.; F. D. Newbury, Chairman, A. I. E. E. Standards Committee; C. E. Stephens, Chairman, A. I. E. E. Finance Committee.

Mr. H. A. Kidder was reappointed a representative of the Institute on the Board of Trustees, Engineering Foundation, Inc., for the three-year term beginning in January 1931. Professor Harold B. Smith was nominated for election byEngineering Foundation, Inc., as a member of the Engineering Societies Research Board for the three-year term beginning in February 1931.

In view of the fact that the fiftieth anniversary of the organization of the Institute will occur in 1934, the President was authorized to appoint a committee to formulate plans, and make recommendations to the Board of Directors, regarding a suitable form of celebration.

Other matters were discussed, reference to which may be found in this and future issues of the JOURNAL.

Rear Admiral Taylor Receives 1931 Fritz Medal

As the unanimous choice of the 16 Past-Presidents,—four from each of the four founder societies, the Civil, Mechanical, Mining and Metallurgical and Electrical engineers,—of whom the Board of Award is composed, the John Fritz gold medal, one of the highest honors bestowed by the engineering profession in America, for 1931 has been awarded to Rear Admiral David Watson Taylor, retired Chief Constructor of the United States Navy. The award was made "for outstanding achievement in marine architecture, revolutionary results of persistent reasearch in hull design, improvement in many types of warships, and distinguished service as Chief Constructor of the United States Navy during the World War."

Admiral Taylor, born in Virginia in 1864, in 1881, entered the United States Naval Academy, and was graduated from it in 1885 with the highest honors ever attained there. He was ordered to take a postgraduate course at the Royal Naval College, Greenwich, England, and this he completed with high honors in 1889. Various investigations were among his early undertakings; one, the suction or hydraulic interaction between two vessels when passing each other. During 1912-1913 he undertook experiments which led to more accurate information on aerodynamic forces, culminating in his building the first wind tunnel to be constructed in this country and for some years the largest and most powerful in the world. Most notable of his national achievements was the halving of the coal bill of the United States Navy by the utilization of the bow wave for ship propulsion, a practise which has been adopted by every navy in the world and recently extended to the merchant marine. During the World War, Mr. Taylor was a member of the Aircraft Production Board; the Shenandoah was designed under his direction and the utilization of the Model Basin for the evolution of flying boat hulls and seaplane pontoons was also due to his creative genius. He was appointed Chief of the Bureau in 1914 and in 1917 was made Rear Admiral. He holds honorary degrees of Doctor of Engineering from Stevens Institute of Technology, Doctor of Science from George Washington University, Doctor of Laws from Randolph-Macon College and Glasgow University, and was the first American to be honored by the gold medal of the British Institution of Naval Architects. He is a Past-President and honorary member of the Society of Naval Architects and Marine Engineers, Vice-Chairman of the National Advisory Committee for Aeronautics, and Commander of the Legion of Honor of France. The United States bestowed upon him its Distinguished Service Medal for exceptionally meritorious service as Chief of the Bureau of Construction and Repair in 1914.

Doctor A. S. McAllister Appointed Assistant Director of the Bureau of Standards

As announced by Doctor G. K. Burgess, Director of the Bureau of Standards, the vacancy created by the resignation of Mr. Ray M. Hudson, December 31, 1929, has been filled by the appointment of Doctor A. S. McAllister as Assistant Director

in Charge of Commercial Standards, a group of four divisions embracing Simplified Practise, Building and Housing, Specifications and Commercial Standards.

Doctor McAllister, who was made a Fellow of the Institute in 1912, accepted the position of Electrical Engineer at the National Bureau of Standards in 1921, and was soon placed in charge of the Bureau's specification work. On July 1, 1929 this work was organized as a separate Division and Doctor McAllister took charge, in this capacity rendering invaluable and unparalleled service to the Bureau in familiarizing local governments with its operation; also displaying a most helpful interest in the field of Home Economics of the Department of Agriculture. Under his direction, the Bureau of Standards has issued many important publications,—the National Directory of Commodity Specifications; Standards and Specifications in the Wood-Using Industries, Directory of Commercial Testing Laboratories and the Significance and Scope of the Certification Plan. For seven years he was Associate Editor of the *Electrical World* and served for three years as its Editor. His activities were also closely allied with the organization and early work of the American Engineering Standards Committee—now the American Standards Association—and his membership in the Illuminating Engineering Society and the Society for the Promotion of Engineering Education has been a representative one. His B. S. degree was granted to him by the Pennsylvania State College in 1898 and E. E. in 1901. His Master's degree in Mechanical Engineering from Cornell University was granted in 1901 and that of Doctor of Philosophy in 1905.

Naval Architects and Marine Engineers Meet November 13-14, 1930

The thirty-eighth General Meeting of the Society of Naval Architects and Marine Engineers will be held in the Engineering Societies Building, 29 West 39th Street, New York, November 13th and 14th, 1930.

The program is inclusive of many papers of high importance in this special field of engineering activity, and the speakers will be men of eminent authority on their respective subjects. There will also be a meeting for the arrangement of papers to be presented during the coming year; also a trip to the Westinghouse Lighting Institute. Communications of inquiry should be addressed to Daniel H. Cox, Secretary-Treasurer, Engineering Societies Building, 33 West 39th Street, New York, N. Y.

The Second Lincoln Arc Welding Prizes are Announced

Designers and engineers in every industry where iron and steel form all or a part of the manufactured product, are again given the opportunity by The Lincoln Electric Company, Cleveland, Ohio, sponsors of the Second Lincoln Arc Welding Prize Competition, to show their skill and ingenuity in utilizing the advantages of arc welded construction. Awards amounting to $17,500 will be distributed in prizes for the forty-one best papers submitted in the competition, as follows:

First prize paper	$7,500
Second prize paper	3,500
Third prize paper	1,500
Fourth prize paper	750
Fifth prize paper	500
Sixth prize paper	250
Seventh to forty-first prize papers	100 each

The Jury of Awards to judge the papers will be composed of the Electrical Engineering Department of Ohio State University under the chairmanship of Professor Erwin E. Dreese, head of the department and Member of the Institute, and such others as he may select.

In announcing this competition, which is the second to be sponsored by The Lincoln Electric Company the sponsors are establishing a biennial competition which should be welcomed by industrial engineers and manufacturing executives throughout the world. The purpose of this Second Lincoln Arc Welding Prize Competition, as announced by its sponsors, is to stimulate designers and engineers in every line of industry to think of the manufacture of their own products by the use of arc welding and to increase their knowledge of the feasibility of its application.

The competition is open to any person in the world except the employees of the sponsors. The closing date for the competition is October 31, 1931. For complete details of the rules governing the competition, address The Lincoln Electric Company, P. O. Box 683, Cleveland, Ohio.

Informal Discussion on International Electrical Organizations at Stockholm, June 1930

The growing number of international organizations in the electrical field has given rise to some concern, especially in Great Britain, and in order to coordinate British participation in international electrical matters, the Institution of Electrical Engineers formed some time ago an International Relations Committee. This committee, through the British National Committee of the International Electrotechnical Commission, invited the I. E. C. to provide opportunity for holding an informal meeting during its technical sessions in Stockholm, to discuss this important question. The Committee of Action of the I. E. C., while assuming no responsibility for opinions which might be expressed at such a meeting, agreed to this arrangement. The meeting was held in the Parliament House and was attended by representatives of 22 nations who were present at the I. E. C. meetings, with Lt. Col. K. Edgcumbe, R. E., Chairman.

The discussion was opened by Mr. Percy Good, Secretary of the British National Committee of the I. E. C. and a member of the International Relations Committee of the Institution of Electrical Engineers, who emphasized the fact that while the committee had asked him to prepare the paper, since the committee did not feel that it could make any specific proposals, it would express his own personal opinion. In making a comparison between the I. E. C. and other international bodies, he showed that the I. E. C. existed for the specific purpose of obtaining agreement on standardization questions, whereas the primary purpose of the other international bodies was the exchange of information and experience, and the bringing into personal contact those engaged in similar work in different countries. Recent experiences, however, had shown that congresses of this kind had already reached the stage of being overburdened with papers, some of which were not up to the standard of, nor appropriate for, international discussion. Mr. Good pointed out the need for coordination in the international field in order to avoid overlapping of effort, and he suggested the possibility of there being some changes in one or the other of the existing organizations, or the merging of some of them into a body which should be representative of the electrotechnical industry throughout the world. Such a body would act internationally in the same way that the American Institute of Electrical Engineers and the Institution of Electrical Engineers in Great Britain do nationally, by the permanent affiliation of a number of electrical engineers in every country. It would thus have available the funds to promote continual international exchange of technical information, and the calling of conferences when necessary; such organizations to be governed by representatives from properly formed national committees, each of which should be responsible for seeing that the papers contributed by members of its own country were of a standard justifying international consideration.

Representatives from the following countries attending the I. E. C. meetings, took part in the discussion which followed:

France, Austria, Belgium, Czechoslovakia, Denmark, Germany, Holland, Japan, Norway, U. S. S. Russia, Spain, Sweden, Switzerland and Italy.

Professor C. Feldman, President, and C. le Maistre, C. B. C., General Secretary of the International Electrotechnical Commission, and Tribot Laspiere, General Secretary of the International Conference on Large Electric High-Tension Supply Systems, the Syndicate of Contractors of Electric Networks and the Syndicate of Manufacturers of Large Electric Plants were in attendance, as were Doctor Clayton H. Sharp, of the Electrical Testing Laboratories and President of the United States National Committee of the I. E. C. (representing the United States); also J. H. Dellinger, of the Bureau of Standards, A. S. Garfield, C. B. LePage, Assistant Secretary of the American Society of Mechanical Engineers. Other Americans present were F. D. Newbury, Manager of the Power Engineering Department, Westinghouse Electric & Mfg. Co., E. B. Paxton, and L. T. Robinson of the General Electric Company.

Electric Welding Committee

The Committee on Electric Welding held a meeting in Chicago, September 24th; P. P. Alexander presiding. The matter of organizing several subcommittees was discussed.

A Subcommittee on Research was appointed, consisting of Messrs. S. Dushman, Chairman, A. M. Candy, H. M. Hobart, J. Slepian, and W. Spraragen. The principal duties of this committee will be the sponsoring of the conduction of research and the presentation of high-grade papers on the phenomenon of the arc, the characteristics of electric circuits utilized in various electric welding processes, etc.

A Subcommittee on Resistance Welding was authorized in view of the great increase in the types and sizes of apparatus used in the resistance welding process; and Mr. E. Lunn was appointed to act upon immediate matters, with the understanding that at a later date the membership may be increased by several additional members.

Design of National Hydraulic Laboratory

This is the title of a pamphlet which has been prepared by Mr. John R. Freeman, Consulting Engineer of Providence, R. I. and Past-President of the A. S. M. E.—describing the new National Hydraulic Laboratory for the construction of which act was passed as published on page 804 of the September 1930 issue of the Institute's Journal. Ransdell Bill, s-3043.

The pamphlet will include copy of the plans, estimates of cost and memoranda relative to the laboratory, and will be known as Document No. 208; copies to be ordered from the United States Printing Office, Washington, D. C.

A New N. E. M. A. Reference Book

A new book of motor and generator standards has just been published by the National Electrical Manufacturers Association. This book is a valuable reference work of practical information on the manufacture, test, performance and application of alternating and direct current motors and generators, frequency converters and motor-generator sets of small and large power capacities.

The volume contains over 550 rules dealing with rating, performance, application and commercial considerations. As well as a large section devoted to the definitions of electrical terms and abbreviations met with in the motor and generator industry. Much of the material is entirely new including ratings for large power d-c. motors and elevator motors, minimum efficiencies and indicated starting currents for fractional horsepower motors, ratings and specification forms for a-c. generators, definitions for squirrel-cage and other motors and the Department of Commerce simplified practise recommendations on carbon brush sizes.

For the first time numerous tables have been added, covering standard horsepower, speed ratings and standard compressor applications, and factors for large direct driving synchronous motors. An entire section is devoted to the standard method of connections and marking of terminals. Price $1.50 per copy. Apply to National Electrical Manufacturers Association, 420 Lexington Ave., New York, N. Y.

Pamphlet on Insulation Testing

A special reprint pamphlet has recently been issued by the A. S. T. M. covering the testing of insulating materials. It contains all of the methods of testing insulating materials prepared by the Society's committee, as well as the annual report of the committee presented at the June meeting. In addition it contains some few specifications prepared by other committees of the society of interest to electrical insulation matters and provides a handy reference for persons interested in the most recent methods of testing insulating materials; approximately 200 pages. Price $1.25.

PERSONAL MENTION

Philip X. Rice, formerly Chief Engineer of the Miller Train Control Corporation has been appointed Development Engineer General Division of Leeds & Northrup Company, Philadelphia, Pa.

A. H. Armstrong is retiring from the General Electric Company after thirty-nine years' service November 1st to open a consulting engineering office in Schenectady.

D. S. Wegg, who has served the American Cyanamid Co. for sometime as Engineer, was recently made Chief Engineer of Consolidated Laundries, New York City.

F. E. Verdin is now working for the Niagara Hudson Power Corporation as Power Sales Engineer in the Oswego District, having severed his connection with the Square D Company on September 15th.

C. Stuart Beattie, formerly with the United Engineers and Constructors, Inc., Newark, New Jersey, has become affiliated with the Delta-Star Electric Co. of Chicago, Illinois, in the capacity of Sales Engineer for the New York District.

Edwin M. Meyer, who has been associated with G. & W. Electric Specialty Co. of Chicago as Electrical Engineer has become Electrical Engineer for Porcelain Products, Inc., and will be located at Parkersburg, W. Va.

D. C. Jackson, Jr., has left his position as head of the department of Mechanical and Electrical Engineering at the Speed Scientific School, University of Louisville, to assume duties as head of the Department of Electrical Engineering, University of Kansas, Lawrence, Kansas.

Edmund D. Ayres, Electrical Engineer, associated for the past six years with the firm of Jackson & Moreland, Engineers, Boston, has accepted the position of Assistant Professor in charge of courses in Central Stations and Power Distribution at the University of Wisconsin.

Edwin S. Oberndorf, formerly with the Electrical Division of The J. G. White Engineering Corporation, is now connected with the Engineering Department of the Board of Transportation of the City of New York, engaged in the design of the proposed vehicular tunnels under the East River.

Ivan Buys who for seven years was with the Kansas Gas and Electric Co., as Supt. of Transmission is now with the United Power and Light Corporation as Chief Engineer. He is located in the general offices of the company at Abilene, Kansas.

James Theron Rood, for a number of years consulting engineer at the University of Wisconsin, has been made Dean of Engineering at the College of Agriculture and Mechanic Arts, State College, New Mexico, and has taken up his work there.

Doctor Rood occupies the place made vacant by the untimely death of the late dean, Ralph W. Goddard.

B. B. BESSESEN has been appointed an Associate Electrical Engineer in the Engineer. Department at Large, Chattanooga, Tennessee, and has accepted a position as Assistant Superintendent of the Muscle Shoals Hydroelectric Development. Mr. Bessesen has been serving as electrical and mechanical designer, City Engineer, Skagit Power Development, Seattle, Washington.

W. R. JUDSON, after thirteen years of service as Manager of the Santiago, Chile District Office of the Allis-Chalmers Manufacturing Company, with charge of its South American operations, has received appointment as Managing Director of Allis-Chalmers (France), a subsidiary of this company in Paris, for its activities in Europe and Northern Africa. Mr. Judson expects to arrive in Paris about November 15th.

R. C. FRYER who for the past twelve years has held a position as Superintendent of the Meter, Laboratory and Test Departments of the Union Gas & Electric Company, has recently become associated with The Thos. J. Corcoran Lamp Co., Cincinnati, Ohio, manufacturers of automotive equipment for years. This company is organizing an Electrical Division, of the engineering of which Mr. Fryer has been placed in charge.

R. D. SCHLEGEL, formerly with the Potomac Electric Power Co., of Washington, D. C., as Assistant Superintendent of Underground Construction, resigned to devote his entire time to his general contracting business in and adjacent to Washington. Mr. Schlegel is operating the Compressed Air Service Co., engaged in general underground gas and electrical installations, street repair work and the rental of contractors' equipment.

JAMES W. OWENS, Director of Engineering of the Welding Engineering and Research Corporation, of New York, was recently awarded the Samuel Wylie Miller Medal by the American Welding Society, for his work in connection with the application of welding to marine construction. Mr. Owens, who is a Fellow of the Institute, was formerly Director of Welding at the Newport News Shipbuilding and Drydock Company, and has acted as a consultant for a number of industrial concerns.

JOHN H. FUNG left the United States for Georgetown, Demerara British Guiana, S. A., where he intends opening a business of his own as distributor for Westinghouse Electric International Company, the Burgess Battery Company, Absopure Refrigeration Corporation, the Pacent Electric Company, the Pacent Reproducing Corporation, the National Company, Inc., and a number of other organizations with which negotiations are not yet completed. Mr. Fung has been acting as Tester for the Radio Corporation of America at the Bush Terminal, Brooklyn.

RUBEN MOITINHO, a former student at the Naval Academy in Brazil, who came to the United States for seven and a half years to study electrical and mechanical engineering at Ohio University and Carnegie College, and who was the only South American delegate to the sessions of the International Electrotechnical Commission, at Copenhagen, Stockholm and Oslo last July, has just returned from Europe to study the Federal and State legislation on water power, generation, transmission, and distribution of electrical energy, for which studies he is commissioned by the future Government of Brazil.

RICHARD M. BOYKIN, formerly Manager of Puget Sound Power & Light Company, Seattle, has resigned to take up new duties with Electric Bond and Share Company, New York. He will be associated with Mr. Frank Silliman, Jr., who gives attention to the Montana Power Company, Washington Water Power Company, Northwestern Electric Company, Portland Gas & Coke Company, Pacific Power & Light Company and affiliated properties. Mr. Boykin has been Chairman of the Portland, Section, and has taken an active interest in the Seattle Section of the A. I. E. E. He was twice President of the Northwest Geographic Division of the N. E. L. A.

S. A. CANARIIS, after five years service with the Duquesne Light Company in its Sales Engineering Department, has accepted a position as Assistant Power Engineer of the Bureau of Water, Department of Public Works, City of Pittsburgh, effective September 1, 1930. He will be in charge of all electrical work in connection with the new 16,000-hp. Brilliant Electric Pumping Station, which is expected to be completed about January 1, 1932. Mr. Canariis was formerly connected with the Alabama Power Company and Hugh L. Cooper & Co. on the Wilson Dam job.

Obituary

Peter A. Coghlin, President and Treasurer of the Economy Electric Company, Worcester, Massachusetts, a Member of the Institute (1922) and one of the leading contractor-dealers of Central Massachusetts, died at Hendersonville, North Carolina, after an extended illness. In Worcester Mr. Coghlin was a widely known business man; he was a graduate of the 1897 class of Worcester Polytechnic Institute from which he held a degree of B. S. in E. E. He has always been engaged in electrical construction work, and in many ways was locally active.

J. Hal Livsey, Manager of the General Electric Company for Detroit and lower Michigan, died suddenly October 4, 1930, while on business in Chicago. Born in Pittsburgh, Pennsylvania, November 21, 1864, he entered, after school and college education in Pennsylvania, the then new electric light industry. In 1890 he joined one of the several concerns which later merged into the present General Electric Company and was sent to Detroit to manage the company's interests there, the office he has held ever since his appointment. He was widely known in business and fraternal circles, was an active member of the Detroit Club, Detroit Athletic Club, Detroit Golf Club, Detroit Boat Club, and Corinthian Lodge No. 241. Mr. Livsey joined the Institute in 1900 as Associate.

William E. Davis, prominent in consulting engineering and an Associate of the Institute (1907), died at Cleveland, Ohio, October 9, 1930. Mr. Davis was a graduate in Civil Engineering from Ohio State University (1895). About this same time taking a leading part in the building of street railway lines in and about Toronto and the Lake Shore Electric Railway in Ohio. He was also Assistant Supervisor for the construction of the St. Louis Division of the Louisville & Nashville Railroad; in fact, much of his work has been in railroad development and construction, acting in the varying capacities of Section Foreman, Assistant Supervisor, Roadmaster, Division Engineer, Principal Assistant Engineer and Engineer of Construction for such undertakings. He was Light and Heat Commissioner for Cleveland and also Chairman of the Arbitration Board of the Detroit Street Railway System.

Joseph Calvin Norton, who was Assistant Chief Draftsman of the Pacific Gas and Electric Co., San Francisco, California, and a member of the Institute's local Section in that city, died September 30th. He was born at Farmington, Illinois, October 23, 1885, and in 1913 was graduated from Armour Institute of Technology with a B. S. degree in hydroelectric engineering. Three years were spent as substation operator of the Commonwealth Edison Company, one year with the Santa Fe Railroad Company at Galveston, on valuation work, four years with the Chino Copper Company at Hurle, New Mexico, as General Electrical Foreman, and one year with the Stone and Webster Engineering Corporation at San Francisco, as Draftsman. It was in June 1921 when he joined the Pacific Gas & Electric Company as draftsman, working his way up to the immediate supervisory charge of the Drafting Department. He was a member of the Tau Beta Pi honorary engineering

society and a 32d degree Mason, and a Shriner. He became an Associate of the A. I. E. E. in 1927.

Harold Lewis Turner of the Electrical Sales Engineering Department of the Aluminum Company of America, Pittsburgh, Pa., died of pneumonia, September 13, 1930. Mr. Turner was a native of the state of Iowa, and after completing high school in 1914, he became a student of Electrical Engineering at the Iowa State College. This was followed by two years at Massachusetts Institute of Technology, from which he held a Master's degree in E. E.; his B. S. in Civil Engineering was obtained from Iowa State College. From 1910 to 1914, during school vacations and after school hours, he was working as operator and trouble man for the Independent Tel. Company, as well as doing wiring and adjusting trouble for several small independent light and power companies. In 1914 he took his first full time position as rodman, levelman and draftsman for a civil engineer. He joined the Institute in 1928 as an Associate and transferred to Member's grade the following year. Notwithstanding the brevity of his experience there was in his work every promise of an active and productive professional career.

Frederick Platt, who was Manufacturing Superintendent in the Motor Department of the River Works of the General Electric Company at West Lynn, Massachusetts, died of pneumonia at Moscow, U. S. S. R., September 21, 1930, where he worked as an adviser in motor production, with other American engineers. He had been with the Motor Department of the General Electric since May 1, 1909. A native of Staleybridge, England, after high school education, he came to America and served an apprenticeship to the machinist's trade with the Mason Machine Works in Massachusetts. For two years he was employed by the Brown & Sharpe Mfg. Co., Providence, R. I., as machinist, after which he became draftsman; later going with the Draper Co., at Hopedale, Massachusetts in like capacity. His first position with the General Electric Company in 1899 was as draftsman; then as Assistant Engineer in the Motor Engineering Department, and for a number of years he was in the D-C. Motor Engineering and Test Departments. In 1919 he was made Manufacturing Superintendent of the Motor Department. Besides being an Associate of the Institute (1919) he was a member of several other engineering organizations.

Charles Kilgour Badger, Special Representative—Engineer for McEvelast, Inc., and a member of the Institute since 1908, when he joined as an Associate, died September 20th at Los Angeles. He was born at Keyes Switch, California, in 1881 and attended Stanford University and the University of Nevada. From 1912 to 1915 he was Division Manager of the Southern Sierra Power Company, Public Utility Company, Riverside, California; then he became Superintendent for the 15,000-kv. electric plant, Cerro de Pasco, Peru, and three years later, joined the American Expeditionary Forces as Captain of the U. S. Signal Corps. From this service he returned with major's rank. In 1920 he became Chief Engineer and General Superintendent of Empresa Electrico, de Guatemala, C. A., in charge of construction and operation of Public Utility System, and General Manager of Empresa Electrico del Norte. In 1922 he returned to California where he was Engineer of the Sanitary District, designing drainage systems and a hydroelectric dredge. From 1926 until 1928 when he retired and established a private practise, he was Assistant to the Chief Operating Engineer, Barquito, Chile. He was a prominent Kern pioneer. Impressive fraternal and American Legion rites marked his last services. He was transferred to the grade of Member of the A. I. E. E. in 1922.

Percy E. Hart, Chief Engineer of the Toronto Hydro-Electric System, and a Fellow of the Institute, died on September 10th after a brief illness. Born in Plymouth, England, January 1870, he removed to Canada while still a boy, where he acquired what he chose to term an "all-around" education. From 1889 to 1891 he served the Brandon Electric Light Company as Manager, then joined the Canadian General Electric Company as Superintendent of Construction for the Maritime Provinces, located at Halifax, N. S.; from 1895 to 1901 he was engaged on the heavier classes of installation work throughout the country—principally in Quebec; from 1901 to 1905, he was in the company's offices handling contracts. This developed into the position of Estimating Engineer at the head office, Toronto, attached to the Contract Sales Department. In 1913 he joined the Toronto Hydro-Electric System interests, first as Managing Engineer and then as Chief Engineer, the position held at the time of his death and one which he had filled with exceptional ability for the extended period for which he was so located. By the profession he was looked upon as a thoroughly dependable, capable and worthy representative of all interests with which he was identified, all of which were in themselves of prominence in electrical engineering fields. Besides his membership in the A. I. E. E. he was also a Fellow of the Canadian Institute of Engineers.

Charles A. Mudge, General Manager of the Electro Dynamic Company, Bayonne, N. J., died October 11, 1930, leaving a record of service in many ways exceptional. A native of Williamsport, Pa., he attended Bucknell University, Lewisburg, Pa. and Cornell University winning from the latter his degree in E. E. His practical work as Chief Engineer of the D-C. Ry. Dept. of Allgemeinen Elektricitats Gesellschaft, Berlin, Germany showed ability. For four years he was employed by the Westinghouse Electric & Mfg. Co., Pittsburgh, Pa. as Engineer. Subsequent connections were as Engineer of the Bullock Electric Company, Cincinnati, Ohio; as Chief Factory Engineer of the Sprague Electric Company, Bloomfield, New Jersey; from 1911 to 1917 he was connected with the U. S. Heat & Light Corporation of Niagara Falls in the capacity of Manager of the Auto Starter and Lighting Department; here he contributed materially toward the development of starting equipment, and for this service received a silver medal award at the Panama-Pacific Exposition at San Francisco, in 1915. He had been with the Electro Dynamic Company since 1917 as General Manager and in this capacity had direct charge of all departments. Under his leadership many special machines for various applications were developed and built. Only recently he was instrumental in introducing a new line of d-c. motors of welded construction. He was active in numerous associations, serving on special and standard committees of both the National Manufacturers Association and the Institute, of which he became an Associate in 1903.

Thornton Lindley High, District Manager of the Pacific Electric Mfg. Corporation, Portland, Oregon, and an Associate of the Institute (1929) died suddenly September 3d in that city. He had served the interests of the Pacific Electric Manufacturing Corporation since August 1925, when he joined the San Francisco office as draftsman in its Engineering Department. He was born in San Francisco, July 21, 1897, his high school education being supplemented by an electrical engineering course under worthy personal tutelage. Upon graduation from high school he went to work with his father who was then President of the Main Iron Works of San Francisco. Here he served an apprenticeship as a machinist, continuing his work by remaining in the drafting room until June 1925. But industrial depression overtook the shop and he left to affiliate himself with the Associated Oil Co. at Avon, California, as draftsman in its Engineering Department. Because of the ill-health of his son, however, it became expedient for him to return to San Francisco, and he at once joined the Pacific Electric Manufacturing Corporation first as draftsman in its Engineering Department and Recording Design Engineer for all airbrake and disconnecting switches, holding this latter position for over a year. During this period of service, Mr. High was continuing his studies in Electrical Engineering under his previous instructor, Mr. Samuel Payne Reed, of San Francisco, and when Mr. Urban N. Halliday, his company's Sales Engineer at Portland, Oregon, was forced to resign because

of ill-health, Mr. High was appointed to succeed him as representative of the company in the Pacific Northwest.

William Falconer McKnight, Professor of Electrical Engineering, Nova Scotia Technical College, Nova Scotia, Canada, died at the Jordon Memorial Sanatorium, River Glade, N. S., where he had recently gone for treatment. Professor McKnight was born at Douglastown, N. B., in 1884, and received his education at Harkins Academy, the Provincial Normal School at Fredericton and Mount Allison and McGill Universities. Following this he entered the field of practical engineering where he showed unusual aptitude for the training of employees in this branch of the profession. Coming to the technical college with a brilliant scholastic record and fine practical training, he entered upon his duties well equipped for that which lay before him. His career although comparatively brief, represented a remarkably well-rounded culture; he had a marked artistic ability which manifest itself in all his undertakings which were carried through with a clarity of purpose, thoroughness, and precision which made for leadership. His character exemplified the attributes of frankness, courage, and reliability. He had served as Acting Secretary of the Board of Engineering Standards under the Research Council of Canada, and under the Council compiled the original Electrical Code for the Dominion of Canada. He was also a member of the Committee on Engineering Physics of the National Research Council; a Past Councillor of the Engineering Institute of Canada and Past Chairman of its Halifax branch. He was also Past-President of the Kiwanis Club of Halifax. He joined the Institute in 1918.

Thomas Sproule, General Superintendent of Distribution of the Public Service Electric & Gas Co., Newark, New Jersey, and looked upon as an expert in public service work, died suddenly in his office at company headquarters October 11th. Born in Philadelphia, November 23, 1878, he was educated in the public schools of that city. After completing high school, he was employed by the Brush Electric Light Company as Draftsman, in which capacity he was closely identified with both station and outside construction. In 1901 he was made Assistant to the Engineer in charge of overhead lines construction and street lighting of the Philadelphia Electric Company; 1902-1905 he was placed in active charge of all underground construction incident to street lighting, installation of conduits, cables, lamp poles, etc., and in the absence of the Chief Engineer of the department, held responsible charge for all departmental work. He was an active factor in many engineering organizations; a member of the National Electric Light Association, the Pennsylvania Electric Association, the Illuminating Engineering Society; the American Railway Association; a member of the N. E. L. A. Committee on Overhead Construction; Chairman of the Pennsylvania Electric Association's committees on Overhead Line Construction, Convention Programs, Public Utility Interconstruction; and secretary of the Philadelphia Electric Company's Section of the N. E. L. A. He assisted in the preparation of the handbook on overhead line construction which is now in very general use in this country, and also participated in the formulation of a national electrical safety code. He joined the Institute as a Member in 1913.

A. I. E. E. Section Activities

NEW YORK SECTION ILLUMINATION AND TRANSPORTATION GROUPS TO MEET DURING NOVEMBER

The month of November will see the first meetings of the Illumination and Transportation Groups for the present administrative year of the New York Section. The Power and Communication Groups already have been together in successful meetings, drawing an unusually large attendance. All Section members who have an interest in any of the Group subjects as presented, whether they feel they logically belong to that particular group or not, are urged to attend. They will find that the subjects are covered in a way that will be understandable to all. The group officers urge you to come, ask your questions of the speakers and take part in the discussion.

Illumination Group: On the evening of Tuesday, November 11, 1930 at 7:30 o'clock the Illumination Group will present a talk on "How to Secure Refined Illumination from Raw Light," by Ward Harrison, Director of Engineering, General Electric Co., Nela Park, Cleveland.

This talk will be a logical continuation of the popular program started last year. With demonstration apparatus, models and latest type of equipment Mr. Harrison will refresh your memories on a subject which is inportant to everyone. The speaker, known throughout the world as one of the leaders in the illumination art, tells his story in a most enjoyable and fascinating manner. At the conclusion of the meeting, those desiring will be taken on a tour of some of New York's most recent installations which demonstrate how the architect is making lighting a component part of structure. The meeting will be held in Room 1, Fifth Floor, Engineering Societies Bldg., 33 West 39th St., New York, N. Y.

Transportation Group: The first meeting of the Transportation Group will be held at 7:30 p. m. on Thursday, November 13, 1930, in Room 1, Engineering Societies Bldg., 33 West 39th Street, New York, N. Y. The meeting will be devoted to the subject of bus transportation. There will be two speakers, as follows: Arthur T. Warner, General Manager in Charge of traffic, Public Service Coordinated Transport, who will talk on "Development of the Bus as a Transportation Vehicle," and E. J. McIlraith, Staff Engineer, Chicago Surface Lines, whose subject will be "Trolley Bus Operation in Chicago." Modern conditions of city traffic require in many cases the adoption of these modes of transportation. The bus, built for straight gas, gas-electric or trolley, has wide application, and each type has a field to which it is best suited. Both companies represented by the speakers are large operators and the speakers are eminently qualified to discuss the specific problems to be met.

FUTURE SECTION MEETINGS

Cleveland

November 20, 1930—*Electrical Features of the New Cleveland Terminal*, by H. W. Pinkerton, Engineer, Cleveland Union Terminal.

December 18, 1930—*Decorative and Architectural Lighting*, by H. H. Magdsick, Executive Engineer, Engineering Dept., Nela Park; Retiring National President of the I. E. S. Joint meeting with Cleveland Chapter, Illuminating Engineering Society. Cafeteria lunch served by G. E. Lighting Institute.

Detroit-Ann Arbor

November 18, 1930—*Lightning Investigations*, by H. T. Seeyle, Detroit Edison Co., and J. R. Eaton, Consumers Power Co. Meeting to be held at Jackson, Michigan.

December 12, 1930—*Patents and Inventions*, by George N. Willitts, Secretary, Michigan Patent Law Association. Joint meeting with Michigan Patent Law Association at the Detroit Edison Auditorium.

Lynn

November 12, 1930—*With Byrd to the Bottom of the World*, by Dr. Lawrence M. Gould, Geologist and Second in Command on

the Byrd Antartic Expedition. Meeting to be held at the First Methodist Church. Ladies invited.

December 3, 1930—*The Fishing Banks and Fishing*, by Bassett Jones, Consulting Engineer, Meyer, Strong & Jones, Inc., Ladies invited.

New York

See above and page 958.

Niagara Frontier

November 21, 1930—Buffalo. Subject to be announced later.

December 19, 1930—*Electric Furnaces in Manufacture of Carborundum and Abrasive Products*, with technical illustrated lecture from the Carborundum Company of America.

Seattle

November 18, 1930—*Some Fundamentals of Illumination, Old and New*, by F. A. Osburn, Professor of Physics, University of Washington.

December 23, 1930—*A Resume of Recent Developments in Predetermination of System Performance*, by Dean H. V. Carpenter, of the College of Mechanic Arts and Engineering, State College of Washington.

JOINT SECTION MEETING IN VIRGINIA

The annual fall two-day joint meeting of the Virginia Sections of the A. S. C. E. and A. S. M. E., and the Southern Virginia Section of the Institute, was held this year at the John Marshall Hotel in Richmond on Friday and Saturday, September 19-20. The total attendance was 139 including 75 visitors. The following program was presented:

FRIDAY MORNING

F. F. Harrington, Chairman, Virginia Section, A. S. C. E., presiding.

The Engineer in His Relation to Public Questions, Edwin F. Wendt, Consulting Engineer, Washington, D. C., Past-President of A. R. E. A.

Virginia Highways, C. S. Mullen, Chief Engineer, Virginia Department of Highways.

The Electrical Transmission System and Its Problems, M. J. Idail, Manager of Engineering, Virginia Public Service Co., Charlottesville, Va.

Discussion by A. C. Rogers, Appalachian Electric Power Company, and G. R. Fulton, Virginia Electric & Power Company.

Luncheon—J. Ambler Johnston, A. S. M. E., presiding.

Address by Col. J. Fulmer Bright, Mayor of Richmond.

FRIDAY AFTERNOON

Inspection trip to plant of American Tobacco Company, and tour of a portion of Richmond battlefields.

FRIDAY EVENING

Informal Dinner—J. H. Berry, Chairman, A. I. E. E. Southern Virginia Section, presiding.

Virginia's Relation to National Development, LeRoy Hodges, Managing Director, Virginia State Chamber of Commerce.

Entertainment and demonstration arranged under direction of Doctor J. O. Perrine, Associate Editor *Bell System Technical Journal*, and W. W. Wheeler, Advertising Manager, C. & P. Telephone Co.

SATURDAY MORNING

Golf at Hermitage Country Club.

Inspection trips to various industrial plants in Richmond.

PAST SECTION MEETINGS

Chicago

The Electron Tube in Electrical Engineering, by O. H. Caldwell, Editor of *Electronics*. Joint meeting with the Western Society of Engineers. preceded by dinner. September 15. Attendance 236.

Cincinnati

Characteristics of Incandescent Lamps, by G. S. Merrill, General Electric Co.;

Correct Wiring Methods, by M. D. Cooper, General Electric Co. Demonstrated. L. L. Bosch gave a report of the Summer Convention held in Toronto. September 11. Attendance 120.

Denver

Coordinating Design, Construction, and Operation, by W. S. Lee, President of the Institute. Dean H. S. Evans, Vice-President, A. I. E. E., North Central District (No. 6), made a few remarks, and Professor Straub of the University of Illinois discussed the subject, *Caustic Embrittlement.* A report of the Summer Convention held in Toronto last June was presented by F. A. Eastom, Delegate of the Section. September 15. Attendance 42.

Detroit-Ann Arbor

The Biology of Civilization, by Professor William D. Henderson, University of Michigan. T. N. Lacy, Vice-President, A. I. E. E. Great Lakes District (No. 5), outlined some of the changes which will be made in the publication of the Institute JOURNAL; also the proposed plan providing prominent lecturers to visit a specified number of Sections on a speaking tour. September 16. Attendance 72.

Erie

Electric Welding of Steel Buildings, by Frank P. McKibben, General Electric Co. Dinner preceded the meeting. September 16. Attendance 70.

Indianapolis-Lafayette

Refinements in Power Plant Design, with Special Reference to the Use of Models, by J. H. Walker, Detroit Edison Co. Joint meeting with the A. S. M. E. May 23. Attendance 38.

Lehigh Valley

Inspection trip to the Research and Test Laboratory of the Lehigh Portland Cement Co. at Ormrod. A moving picture showing in detail the many processes involved in the manufacture of cement was exhibited. Following luncheon, which was provided by the Lehigh Portland Cement Co., the inspection trip left Ormrod with a State Highway Patrol escort to the Sandts Eddy Plant, where the wet process of manufacturing cement was covered, from the removal of the limestone rocks from the quarry to the bagging of the finished product. Professor Morland King presided at the dinner and entertainment which followed. September 27. Attendance 320.

Minnesota

D. K. Lewis, Chairman, outlined plans for the ensuing year and asked for suggestions as to the best means which might be used to increase the attendance at meetings. As a result of considerable discussion, a committee was appointed to review the entire situation. Talks on football followed. October 1. Attendance 37.

Nebraska

Coordinating Design, Construction, and Operation, by W. S. Lee, President of the Institute. Mr. Lee also reviewed Institute activities and talked informally about three interesting projects in which his company was engaged. President Lee was entertained at dinner by the officers of the Section. September 17. Attendance 25.

Niagara Frontier

Three Years' Progress in Field Investigations with Artificial Lightning, by K. B. McEachron, General Electric Co. Illustrated. Informal dinner in honor of the speaker preceded the meeting. September 19. Attendance 60.

Oklahoma City

New Engineering Problems Encountered in Talking Movies, by J. Eldon Peek. A discussion of plans for the ensuing year preceded the presentation of this paper. September 29. Attendance 56.

Pittsburgh

Inspection trip to the West Penn Power Company's Springdale power plant and coal mine. Joint meeting with the Engineers Society of Western Pennsylvania. September 16. Attendance 262.

Portland

Modern Lightning Arrester Developments, by J. Slepian, Westinghouse Elec. & Mfg. Co. Joint meeting with the Technical Section of the N. E. L. A. September 30. Attendance 75.

St. Louis

Motor Requirements for Modern Heating, by H. Weichsel, Wagner Electric Corp. C. B. Fall gave a report of the Summer Convention held at Toronto, which he attended as the Delegate of the Section. September 17. Attendance 72.

San Antonio

Mechanical Features of Automatic Adjustable Blade Water Turbine at Devil's River Plant, by C. L. Dowell, Central Power & Light Co.; *Electrical Features of Devil's River Plant*, by M. H. Lovelady, Central Power & Light Co. Chairman D. W. Flowers gave a report on the Summer Convention at Toronto, which he attended as the Delegate of the Section. September 22. Attendance 49.

Spokane

Nature of the Electric Arc, by J. Slepian, Westinghouse Electric & Mfg. Co. October 3. Attendance 39.

San Francisco

Coordinating Design, Construction, and Operation, by W. S. Lee, President of the Institute. Following his address, Mr. Lee outlined the aims and activities of the Institute, and also described a unique construction job recently completed under his direction. O. K. Marti, American Brown Boveri Co., gave a talk on oil circuit breakers, illustrated with two reels of motion pictures. On behalf of the San Francisco Section, President Lee presented Allen G. Jones, with a certificate of appreciation acknowledging eighteen years of service as Secretary of the Section. September 8. Attendance 116.

Executive Committee meeting. September 16. Attendance 8.

Circuit Interrupters, by J. Slepian, Westinghouse Electric & Mfg. Co. Brief discussions followed by J. P. Jollyman, S. J. Lisberger, and E. A. Crellin. Dinner preceded the meeting at the Engineers' Club. September 26. Attendance 155.

Springfield

Manufacture of Glass, by K. K. Knaell, Macbeth-Evans Glass Co. Illustrated with motion pictures. Mr. Knaell also told some of the history of glass making. September 8. Attendance 48.

Toledo

Marine Applications of Electricity, by F. V. Smith, General Electric Co., illustrated. T. J. Nolan, Chairman, Membership Committee, reported that good progress was being made in securing new members, and he also urged that all qualified Associates now paying $15 dues apply for transfer to the higher grades. I. H. Heitkamp, Chairman, Program Committee outlined the plans of his committee for the year. September 19. Attendance 55.

Toronto

Annual Get-Together Night. I. M. MacLean, Chairman, Membership Committee, discussed the advantages of membership in the Institute, and outlined plans for this season's membership campaign. A. B. Cooper, Director, A. I. E. E., gave a short talk on Institute affairs. Entertainment followed. September 26. Attendance 70.

Utah

Coordinating Design, Construction, and Operation, by W. S. Lee, President of the Institute. President Lee opened his remarks with a brief discussion of Institute affairs,—chiefly the changes in the Institute JOURNAL. Dinner preceded the meeting. September 12. Attendance 44.

Vancouver

Operating Characteristics of Transformers, by F. T. Wyman, Packard Electric Co., Ltd. Reports from J. Teasdale, on his trip to the Summer Convention at Toronto in June, and from R. L. Hall, on his trip to the Pacific Coast Convention at Portland, were read. October 6. Attendance 46.

Washington

Oscillograph Applications, by C. Anderson, Westinghouse Electric & Mfg. Co. Dinner in honor of the speaker preceded the meeting. October 6. Attendance 166.

A. I. E. E. Student Activities

STUDENT ACTIVITIES AT DISTRICT MEETING IN PHILADELPHIA

A joint luncheon meeting of the Counselors and Chairmen of Branches in the Middle Eastern District (No. 2) was held on Monday, October 13, the first day of the District Meeting in Philadelphia. Brief addresses were given by E. C. Stone, Vice-President, and H. H. Henline, Assistant National Secretary, the former dealing with essentials in the training of an engineer, and the latter with the work of the Branches and the results being secured.

The following program was presented at the District Conference on Student Activities held on Monday afternoon, Professor H. E. Dyche, Chairman, District Committee on Student Activities, presiding:

Address—William S. Lee, President, A. I. E. E.

How to Stimulate Student Interest in Branch Meetings, by S. E. McKibben, Chairman, Pennsylvania State College Branch.

A Consideration of the Function of Student Branches, by G. F. Leydorf, Chairman, Ohio State University Branch, and L. Fussell, Jr., Chairman, Swarthmore College Branch.

The Counselor's Duties in a Well Organized Student Branch, by Professor H. B. Dates, Counselor, Case School of Applied Science.

A Review of Student Branch Activities in District No. 2, by Professor Morland King, Counselor, Lafayette College Branch, and Vice-Chairman, Committee on Student Activities of District No. 2.

In a very impressive address, President Lee emphasized the necessity of proper training and experience for the young engineers who will soon be carrying on the important work of the Institute as well as bearing heavy responsibilities in their employment, saying that success is won principally by doing common things in uncommon ways.

Some of the topics on the program aroused a considerable amount of discussion among both Counselors and Chairmen.

On Tuesday, the Counselors and Branch Chairmen held separate luncheon meetings. The Counselors decided that a Conference on Student Activities will be held during the District Meeting in Pittsburgh in March 1931. Professor Morland King, Counselor, Lafayette College Branch, was elected Chairman of the District Committee on Student Activities, and Professor J. T. Walther, Counselor, University of Akron Branch, was elected Vice-Chairman and Secretary; both to take office immediately.

A vote of appreciation was extended by the Counselors to Past-President Harold B. Smith for his leadership in the adoption of the new provisions regarding Student enrolment.

BRANCHES ORGANIZED AT HARVARD UNIVERSITY AND UNIVERSITY OF BRITISH COLUMBIA

The formation of Student Branches of the Institute at Harvard University and the University of British Columbia was authorized by the Board of Directors at its June meeting. Both have completed their organization, and the officers and Counselors named below are in charge:

Harvard University: Professor Chester L. Dawes, Counselor; J. H. Wright, Chairman; P. R. Lincoln, Secretary-Treasurer.

University of British Columbia: Professor E. G. Cullwick, Counselor; M. A. Thomas, Chairman; E. M. Kershaw, Secretary-Treasurer.

PAST BRANCH MEETINGS

University of Alabama

Talks on the benefits of Student enrolment, by W. H. Croft, H. B. Hendrix, and W. R. McClure. Paul Clark outlined the regulations for the presentation of Student papers at the District Meeting to be held in Louisville in November. September 22.

University of Arkansas

Smoker. Professor W. B. Stelzner, Counselor, gave a short talk on the aims and activities of the Institute. Refreshments served. September 25. Attendance 30.

General discussion and committee appointments announced. October 9. Attendance 22.

Armour Institute of Technology

Business meeting. October 6. Attendance 54.

University of California

Initiation banquet, followed by the presentation of three papers:

The Engineer and His Profession, by V. Fant, Student;

The Opportunities for Many Types of Engineers, by L. F. Fuller, Professor of Elec. Eng., Univ. of California;

The Young Engineer and His Work, by F. Blocksom. Two-reel film, "Oil Circuit Breakers." L. E. Reukema, Counselor, acted as toastmaster. September 19. Attendance 62.

Steam Power for Airplanes, by E. J. Hopwood, Student, A.S.M.E.;

Fuel Conversion, by F. S. Cummings, C. C. Moore Company. Joint meeting with the A. S. M. E., preceded by a short business meeting. October 1. Attendance 30.

Carnegie Institute of Technology

What the Branch May Mean to the Individual, by Professor G. Porter, Counselor. Short talk by Professor B. C. Dennison on the advantages of Student enrolment. October 9. Attendance 41.

Clemson Agricultural College

Discussion of the value of enrolment in the A. I. E. E. was given by Professor S. R. Rhodes, Counselor, and C. E. Jarrard, Branch Chairman. September 26. Attendance 25.

Colorado State Agricultural College

Professor F. L. Poole, Counselor, and Professor Batchelder outlined the advantages of Student enrolment in the Institute. September 15. Attendance 21.

University of Colorado

Get-Together Meeting. Short talks on the advantages of Student enrolment, by Professor W. C. DuVall, Counselor, and Dean H. S. Evans, Vice-President A. I. E. E. Professors M. S. Coover and W. L. Cassel outlined their summer experiences. October 8. Attendance 72.

University of Detroit

General Principles of Illumination, by E. F. Labadie, Fisher Body Corp. Film, "The Audion." October 2. Attendance 35.

University of Florida

Talk on the privileges and advantages of being an enrolled Student of the A. I. E. E., by J. E. Weil, Counselor. Short address of welcome by Clyde Booth, Branch Chairman. September 29. Attendance 25.

University of Iowa

Election of officers as follows: J. Westley Campian, Chairman; Ronald Blough, Vice-Chairman; Don A. Cozine, Secretary-Treasurer. Professor Edwin Kurtz, Counselor, gave a talk concerning the papers which will be given by students periodically throughout the year. September 24. Attendance 42.

The History and Advantages of the A. I. E. E., by J. Westley Campian, Branch Chairman. October 1. Attendance 53.

Kansas State College

Professor R. G. Kloeffler, Counselor, outlined the aims and and purposes of the Institute. R. I. Cousins gave an illustrated talk on his summer experiences as an electrician in the coal fields of Southern Illinois. September 18. (Afternoon session).

The program of the evening meeting was the same as that presented in the afternoon. September 18. (Evening session).

Lewis Institute

Election of officers as follows: C. B. Frellsen, Chairman; K. J. Sinclair, Secy.-Treas. October 2. Attendance 34.

University of Louisville

When Trade Acquires World Vision, by Theodore Kraft. Farewell meeting held jointly with the A. S. M. E. Branch, in honor of Professor D. C. Jackson, Jr., who has left Louisville. August 8. Attendance 23.

Marquette University

Executive Committee meeting. September 25. Attendance 9.

Illustrated talk on light, power, and gas distribution, and electrical transportation in and around Milwaukee, by Mr. Engelhart, Milwaukee Electric Railway and Light Co. October 2. Attendance 40.

University of Michigan

Election of Officers as follows: Allen D. Forbes, Chairman; H. N. Van Aken, Vice-Chairman; Gary Muffly, Secretary; C. W. LeSage, Treasurer. Short address by Professor B. F. Bailey, Counselor, explaining the advantages of Student enrolment in the Institute. October 9. Attendance 60.

Missouri School of Mines & Metallurgy

Election of officers as follows: J. D. Shelton, Chairman; A. R. Baron, Vice-Chairman; G. L. Leisher, Secy.-Treas. *Purposes and Aims of the A. I. E. E.*, by Professor I. H. Lovett, Counselor. October 2. Attendance 27.

University of Missouri

Membership and Benefits Derived from A. I. E. E., by Professor M. P. Weinbach, Counselor. October 7. Attendance 18.

Montana State College

The Advantages of Chromium Plating, taken from the *Electric Journal*, presented by Earl Doney, Student;

The Condenser Reproducer, taken from *Projection Engineering*, presented by Joe Hurst, Student;

Railroad Electrification, taken from the *Electric Journal*, presented by Robert Erb, Student. October 9. Attendance 159.

University of Nevada

Research Studies in the Development of Extremely High Resistances in Vacuum Tubes, by L. P. Smith, California Institute of Technology. September 26. Attendance 41.

Newark College of Engineering

Talk by H. H. Henline, Assistant National Secretary of the Institute, on the Student Branches of the A. I. E. E. October 6. Attendance 39.

University of New Mexico

Discussion of plans for future meetings. October 7. Attendance 11.

College of the City of New York

Discussion of plans for future meetings. September 25. Attendance 10.

North Carolina State College

History and Purpose of National Institute, and *History and Purpose of the Student Branch*, by J. B. Curley, Student;

Benefits of the A. I. E. E., by Professor R. S. Fouraker, Counselor;

What You Get for Your Money and *Functions of the A. I. E. E.*, by R. C. Kirk, Branch Chairman. October 8. Attendance 121.

North Dakota State College

Organization meeting. October 9. Attendance 102.

University of Notre Dame

The Advantages of Being an Institute Member, by Professor J. A. Caparo, Counselor;

The Development of Engineering as a Profession, by Edward Conroy, The Ohio Bell Telephone Co. Committee appointments announced. October 6. Attendance 82.

Ohio Northern University

Smoker. October 6. Attendance 30.

Oklahoma A. & M. College

M. C. Brady, Student, outlined the experiences encountered during his summer engineering work. September 25. Attendance 12.

University of Oklahoma

Discussion of plans for future meetings. October 1. Attendance 14.

Oregon State College

Review of the Pacific Coast Convention held in Portland in September, by Glen Barnett, Branch Chairman, and Professor F. O. McMillan, Counselor. Professor McMillan also enumerated the advantages of membership in the A. I. E. E. October 6. Attendance 18.

University of Pennsylvania

The aims and activities of the Institute were outlined by W. D. Bruce, Branch Chairman. Refreshments and bridge followed. September 30. Attendance 23.

General discussion, and a short talk by Professor C. D. Fawcett. October 6. Attendance 19.

University of Pittsburgh

Election of officers as follows: W. J. Howell, Chairman; D. N. Burdette, Vice-Chairman; R. H. Kernahan, Secretary. September 25. Attendance 120.

R. G. MacDonald, Student, spoke on his experiences with a line crew while working for the West Penn Power Co. J. B. Luck, General Electric Co., outlined what the student may expect after graduation. October 2. Attendance 98.

Pratt Institute

John E. Cook, Chairman, outlined the intended activities for the coming year, and familiarized the new students with the A. I. E. E., pointing out its purposes and urging them to join. September 25. Attendance 52.

Power Distribution in the Metropolitan Area, by John E. Cook, Branch Chairman. October 9. Attendance 65.

Inspection trip through the Hudson Street Power Plant of the Brooklyn Edison Co. October 11. Attendance 68.

Purdue University

Professor A. N. Topping, Counselor, gave a history of the activities and development of the A. I. E. E. Professor C. F. Harding outlined the research program being carried on at Purdue. September 30. Attendance 225.

Rhode Island State College

My Experiences in the Bell Telephone Laboratories, by J. F. Schmidt, Student. Report on the District meeting held in Springfield in May 1930 by G. Verros, Branch Chairman. September 22. Attendance 15.

The Problems Confronting the Engineering Graduate, by E. A. Billmeyer, Assistant Professor of Civil Engineering. September 29. Attendance 15.

Film, "Liquid Air," followed by a short business meeting. October 6. Attendance 30.

University of Santa Clara

Reading of By-laws. The advantages of Student enrolment were explained and all students were urged to enroll. William Warren, Branch Chairman, gave a report of the Pacific Coast Convention held in Portland, September 2-5. September 17. Attendance 60.

Theoretical Considerations of the Sound Movies, by L. W. Thorpe, Student. September 24. Attendance 103.

University of South Dakota

Booklets describing the Institute were distributed among the students and all were urged to enroll. September 25. Attendance 11.

University of Southern California

Dean Biegler gave a short talk on the history and work of the Branch. Professor Angermann, Counselor, spoke of the need to start work on the Student papers early. Rodney Lewis, Branch Chairman, outlined the events at the Pacific Coast Convention in Portland. September 17. Attendance 47.

R. E. Rowley, Los Angeles Bureau of Power & Light, gave a talk on the many engineering problems encountered by the operating department of a large power company. September 24. Attendance 36.

T. N. Blakeslee, Bureau of Power & Light, gave a talk on the use of safety posters to cut down accidents in the electrical industry, and compared those used in France with those used in this country. October 1. Attendance 25.

Short talks on the aims and purposes of the A. I. E. E., by H. W. Hitchcock, Chief Engineer, Southern California Telephone Co., Chairman Los Angeles Section. October 8. Attendance 39.

Syracuse University

Election of officers as follows: Donald Robinson, Chairman; Willis Kleppinger, Secretary. Charles Root, Student, outlined his experiences while employed by the N. Y. Edison Co., working in the direct current system. W. Kleppinger, Student, related his experiences with the same company in the a-c. districts. September 26. Attendance 25.

My Summer Work with the Bell System, by Richard W. Stone, Student;

The Syracuse Repeater Station, by John T. Henderson, Student. October 3. Attendance 25.

Electrical Control and Operation of a Steel Strip Mill, by J. A. Cermack, Student;

The Electrolysis of Pipe Lines, by L. A. Depew, Student. October 10. Attendance 24.

Texas A. & M. College

H. C. Dillingham, Counselor, and T. M. Sowell, Branch Chairman, spoke on the aims and purposes of the Institute. September 29. Attendance 100.

University of Vermont

Professor L. P. Dickinson, Counselor, spoke on the work of the Institute and explained the advantages of membership in it. September 23. Attendance 24.

Uses of the Photoelectric Cell, by R. F. Bigwood, Student. Demonstrated. October 7. Attendance 28.

Virginia Military Institute

Some Developments in the Electrical Industry During 1929, by C. G. King, Student;

More Ships and Busier Shipyards, by J. P. Bond, Student;

The Status of the Young Engineer, by G. T. Carson, Student. September 19. Attendance 47.

Virginia Polytechnic Institute

Discussion of mechanism and use of oil circuit breakers. R. E. McDaniel elected Secretary. September 24. Attendance 16.

E. L. Rowell and D. H. Smith, Students, gave talks on their summer employment experiences. October 7. Attendance 23.

Washington University

Discussion of plans for future meetings. October 2. Attendance 20.

West Virginia University

Election of officers as follows: P. J. Johnson, President; C. B. Withers, Vice-President. C. F. Stewart, Secretary; H. V. Locker, Treasurer. September 22. Attendance 34.

The following papers presented by Students:

The Development of the Electric Light, by G. Harvey;

Safety at Night for the Aviator, by S. Boone;

Oil Electrics Feature One-Man Operation, by C. F. Stewart;

Life of George Westinghouse, by G. Kennedy;

New Type of Transmission Line Tower, by J. R. Nottingham. September 29. Attendance 34.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, together with the addresses as they now appear on the Institute records. Any member knowing the present address of any of these members is requested to communicate with the Secretary at 33 West 39th St., New York.

All members are urged to notify Institute Headquarters promptly of any changes in mailing or business address, thus relieving the member of needless annoyance and assuring the prompt delivery of Institute mail through the accuracy of our mailing records, and the elimination of unnecessary expense for postage and clerical work:

Cole, C. M., 1814 Grove St., Berkeley, Calif.
Ellenwood, Warren E., 1100 E. 177th St., New York, N. Y.
Gailun, Ben, P. O. Box 257, Angola, Ind.
Ghous, Shah G., P. O. Box 733, Schenectady, N. Y.
Gorrissen, Chas., Hermannstrasse 38, Hamburg, Germany
Grybek, John, 1575 Alice St., Oakland, Calif.
Holroyd, H. B., Dept. of Mech. Eng., Calif. Inst. of Tech., Passadena, Calif.
Jones, D. Brainerd, 4306 45th St., Sunnyside, L. I.
Keegan, W. G., 767 Maple Ave., Los Angeles, Calif.
McDougall, D. J., 1501 W. Pierce St., Phoenix, Ariz.
McLaughlin, R. A., 203 Oley St., Reading, Pa.
Pearson, Ernest, c/o Brewster, Marley Rd., Hartsdale, N. Y.
Schnake, H. C., 7 E. 42nd St., New York, N. Y.
Syed, Mustafa, 93-30 86 Road, Woodhaven, L. I.

Engineering Societies Library

The Library is a cooperative activity of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers. It is administered for these founder societies by the United Engineering Society, as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West Thirty-ninth St., New York.

In order to place the resources of the Library at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies or translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged.

The Director of the Library will gladly give information concerning charges for the various kinds of service to those interested. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The library is open from 9 a. m. to 10 p. m. on all week days except holidays throughout the year except during July and August, when the hours are 9 a. m. to 5 p. m.

BOOK NOTICES—SEPTEMBER 1-30, 1930

Unless otherwise specified, books in this list have been presented by the publishers. The Institute does not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

AIDE-MEMOIRE.

By J. Claudel. 12th ed. Paris, Dunod, 1930. 2 v., 2296 pp., illus., diagrs., tables. 9 x 5 inches, cloth. 259, 60 fr. 2 v.

This well-known handbook, first published in 1846, appears in a newly revised edition. Little change has been made in its scope, the principal emphasis still being upon hydraulic engineering, roads, railroads and sanitary engineering, but there are sections devoted to mechanics, industrial physics, steam and gas engines, and electrical engineering. A useful summary of current French practise.

APPLIED MECHANICS.

By Norman C. Riggs. N. Y., Macmillan Company, 1930. (Engineering Science Series). 328 pp., 9 x 6 in., cloth. $3.75.

A college text-book based on the course given to engineering students at the Carnegie Institute of Technology. A working knowledge of integral calculus is assumed. Emphasis is directed toward material of engineering interest.

DIE ELEKTRIZITÄTSGESETZEGEBUNG DER KULTURLÄNDER DER ERDE.

By G. Siegel. Berlin, V. D. I. Verlag, 1930. 3 v., 8 x 6 in., bound. Contents: v. 1, Deutschland; v. 2, Westeuropa; v. 3, Nord-und Osteuropa.

A compilation of the laws and regulations governing the generation, transmission and sale of electricity in the different countries of Europe.

ELEKTROPHYSIK DER ISOLIERSTOFFE.

By Andreas Gemant. Berlin, Julius Springer, 1930. 222 pp., diagrs., tables, 9 x 6 in., bound. 21, 50 r. m.

Treats of the dielectric properties of insulating materials and of puncture phenomena. The discussion aims to supply engineers with information upon the physical and mathematical questions involved, and to give the student of physics an understanding of the problems that are most important from the engineering point of view.

ENGINEERING.

By Alexander Purves Gest. N. Y., Longmans, Green & Co., 1930. (Our debt to Greece and Rome). 221 pp., 8 x 5 in., cloth. $2.00.

An interesting account of Greek and Roman engineering, intended to set forth our debt to the engineers of antiquity. The materials and methods of construction that they used, their work as builders of aqueducts, roads, bridges, and hydraulic works, and as town planners are described briefly, in language comprehensible to the general reader. A useful bibliography is given.

ESSAI D'HYDROGÉOLOGIE.

By Ed. Imbeaux. Paris, Dunod, 1930. 704 pp., illus., maps, tables, 11 x 8 in., cloth. 297,10 fr.

Dr. Imbeaux here brings together the results of his long experience in this treatise on hydrology. Methods of determining the presence and amount of underground water, its quality and properties are given, together with a survey of hydrological conditions in western Europe and the United States.

EXPERIMENTELLE UNTERSUCHUNGEN AN SCHNELLAUFENDEN KLEINMOTOREN.

By Albert Geissler. Mün. u. Ber., R. Oldenbourg, 1930. 69 pp., illus., diagrs., tables, 9 x 6 in., paper. 5.-r. m.

Gives the methods used and the results obtained in an investigation of small high-speed internal-combustion engines. The exhaust losses and the efficiency of fuel utilization were investigated in a two-cycle engine with crank-case compression, and the mathematical relations developed. An appendix gives the results of comparative tests of four-cycle and two-cycle engines of the same size.

FUNDAMENTAL THEORY OF ELECTRICAL ENGINEERING.

By Arthur Albert. Bost. & N. Y. Ginn & Co., 1930. (Engineering Series) 323 pp., diagrs., tables, 9 x 6 in. Cloth, $3.20.

In preparing this introduction the author has kept in mind the growing tendency toward less specialization in the undergraduate course, and the increasing interest in light-current engineering. He has therefore confined himself to the fundamental electrical phenomena, without overemphasizing their application to any particular branch of practise, but with a detailed treatment of them.

DER EHRENSAAL DES DEUTSCHEN MUSEUMS.

By W. Exner. (Deutsches Museum Abhandlungen und Berichte, v. 2, No. 2). Berlin, V. D. I. Verlag, 1930. 64 pp., ports., 8 x 6 in., paper. 1.-r. m.

A brief guide to the Hall of Honor of the Museum, with a list of the noted scientists and engineers represented; and reproductions of some of the portraits.

GENERATING STATIONS; Economic Elements of Electrical Design.

By Alfred H. Lovell. N. Y., McGraw-Hill Book Co., 1930. 359 pp., illus., diagrs., tables, 9 x 6 in., cloth. $4.00.

Explains the way in which economic principles are applied in the selection of apparatus for power plants and transmission systems, in proportioning the details of an assembly, and in balancing initial and subsequent costs. Attention is given to the interrelation of mechanical and electrical elements of the design, and the special features for which the electrical engineer alone is responsible are analyzed in detail.

GEWICHTSVERLEGUNG UND AUSNUTZUNG DES REIBUNGSGEWICHTES BEI ELEKTRISCHEN LOCOMOTIVEN MIT EINZELACHSANTRIEB.

By H. G. Lindner. (Forschungsarbeiten . . . No. 333). Berlin, V. D. I. Verlag, 1930. 25 pp., illus., tables, 12 x 9 in., paper. 5.-r. m.

A study undertaken to determine the arrangement of motors and springs which will most effectively utilize adhesion. Calcu-

lations are given for all the usual varieties of electric locomotives of the type in question, and tables showing the results.

HEAT ENGINES.

By Charles N. Cross. N. Y., Macmillan Co., 1930. (Engineering Science Series). 607 pp., illus., tables, 9 x 6 in., cloth. $6.00.

The author has endeavored to prepare a textbook that would contain within reasonable bounds an adequate treatment of the fundamental laws of gases and the laws of thermodynamics together with descriptions of the modern forms of prime movers, their operating characteristics, and representative performance results of each type and size. The work represents the course at Stanford University. It is attractively written and illustrated. An unusually large amount of space is given to steam turbines.

DIE KRAFTWIRTSCHAFT, Bd. 1.

By Hans Balcke. Mün. u. Ber., R. Oldenbourg, 1930. 680 pp., illus., diagrs., plates, tables, 9 x 6 in., cloth. 38.-r. m.

A practical treatise on planning and erecting power plants. The first volume discusses the technical elements of steam, internal-combustion, and hydraulic plants, and their combination in plant design. The book gives a good survey of modern practise in Germany.

MACRAE'S BLUE BOOK AND HENDRICKS COMMERCIAL REGISTER, v. 38, 1930. Chicago & N. Y. MacRae's Blue Book Co., 1930. 3308 pp., 11 x 9 in., cloth. $15.00.

This well-known directory supplies an extensive list of manufacturers of materials and machinery of all kinds, classified by products; a directory of manufacturers and dealers, a list of trade names; and a gazetteer of towns with a population of one thousand or more, with information on their trade facilities. A special section, added for the first time, gives the same information for Canada.

MECHANICS: A TEXT BOOK FOR ENGINEERS.

By James E. Boyd. 2nd ed. N. Y. McGraw-Hill Bk. Co., 1930. 384 pp., illus., diagrs., 9 x 6 in., cloth. $3.50.

This text aims to emphasize fundamental principles, illustrate them by examples designed for that purpose and to supply problems that will train the student in their application. Algebraic and graphical methods are developed concurrently in statics, as are work and energy, and force and acceleration, in kinetics. The new edition has been rearranged and partly rewritten, and revised by the inclusion of the British unit of work, the slug.

MECHANICS FOR STUDENTS OF PHYSICS AND ENGINEERING.

By Henry Crew and Keith K. Smith. N. Y. Macmillan Co., 1930. 371 pp., diagrs., tables, 9 x 6 in., cloth. $4.00.

A presentation of the fundamentals of mechanics adapted to the time usually allotted to the subject in engineering colleges. Vectorial methods are used freely, and an essentially historical method of presentation adopted.

MERCURY ARC POWER RECTIFIERS; Theory and Practice.

By Othmar K. Marti and Harold Winograd. N. Y., McGraw-Hill Book Co., 1930. 473 pp., illus., diagrs., 9 x 6 in., cloth. $6.00.

Explains the operation of the rectifier, derives the mathematical relations of currents and voltages in rectifier circuits, and outlines current practise in the use of steel-enclosed rectifiers, with emphasis on their employment in railroad service. Contains a lengthy bibliography.

OBJECTIVE TYPE TESTS IN ENGINEERING EDUCATION AS APPLIED TO ENGINEERING DRAWING AND DESCRIPTIVE GEOMETRY.

By Clair V. Mann. N. Y., McGraw-Hill Book Co., published for Engineering Foundation, Inc., 1930. 122 pp., illus., charts, tables, 9 x 6 in., cloth. $2.75.

Presents tests in engineering drawing and descriptive geometry developed and used at the Missouri School of Mines to determine aptitudes and previous training on the part of entering students, and also to measure their classroom accomplishment. The book describes the tests and the methods of using them and gives a number of representative tests.

DIE RELAISSTEUERUNGEN DER MODERNEN STARKSTROMTECHNIK.

By Reinhold Rüdenberg. Berlin, Julius Springer, 1930. 79 pp., illus., diagrs., 9 x 6 in., paper. 7,50 r. m.

A concise account of modern applications of control apparatus, by the chief engineer of the Siemens-Schuckertwerke. Present tendencies are discussed, the field of control apparatus described and the elements of relays and switches explained. The principle of their action is presented and examples of their use given.

SCHWINGUNGSTECHNIK; bd. 1; Grundlagen. Die Eigenschwingungen eingliedriger Systeme.

By Ernst Lehr. Berlin, Julius Springer, 1930. 295 pp., illus., diagrs., 9 x 6 in., bound. 25, 50 r. m.

The first volume of a series designed to discuss the question of vibration from the practical engineer's and machine builder's point of view, without the use of higher mathematics. This volume is devoted to general principles and simple cases.

TABLES ANNUELLES DE CONSTANTES ET DONNÈES NUMERIQUES . . . v. 7, pt. 1-2.

Compiled by Le Comité international. N. Y. McGraw-Hill Book Co., Paris, Gauthiers-Villars et Cie. 2 v., 1896 pp., diagrs., 11 x 9 in., cloth. $25.00 per set.

This annual summary of chemical, physical and engineering facts reviews the new constants and numerical data that have appeared in any of the leading periodicals of the world. Because of its completeness and convenience, it is almost indispensable to research workers in every line. It forms, also, a supplement to the International Critical Tables. The present volumes cover the years 1925 and 1926.

TEXTBOOK OF SOUND.

By A. B. Wood. N. Y., Macmillan Co., 1930. 519 pp., illus., diagrs., 9 x 6 in., cloth. $6.50.

Covers a much wider field than that usually included under the word "sound," for Dr. Wood treats of vibrations of all frequencies, audible or otherwise. Side by side with the earlier work of Rayleigh and Lamb, he presents the new methods of investigation and the new theoretical developments that have arisen, and also calls attention to the many technical applications of today. He has produced an admirable textbook for university students, and also a convenient reference book for physicists and engineers.

THE VOLATILITY OF MOTOR FUELS.

By George Granger Brown. (Engineering Research Bulletin, No. 14) Ann Arbor University of Michigan, Dept. of Engineering Research, May 1930. 299 pp., illus., diagrs., tables, 9 x 6 in., paper. $1.00.

Although the use of fuels of different volatility has been shown to have no noticeable effect on the power output or fuel consumption of motors operated under full throttle, this is not the case when motors operate at part throttle or when a warm motor is being accelerated. This bulletin gives the results of tests undertaken to determine the effect of variations in volatility upon the behavior of fuels under these conditions. The tests are reported in detail, with conclusions regarding the effect of fuel volatility upon engine performance.

WAVE MECHANICS OF FREE ELECTRONS.

By G. P. Thomson. N. Y., McGraw-Hill Book Co., 1930. 172 pp., illus., diagrs., port., tables, 9 x 6 in., cloth. $2.50.

Contains a course of lectures delivered at Cornell University. The aim is to state the principles and application of the new wave mechanics, in so far as they concern electrons not forming part of an atom. The presentation is made with a minimum of mathematics.

WILLIAM L. SIBERT, The Army Engineer.

By Edward B. Clark. Phila., Dorrance & Co., 1930. 206 pp., illus., ports., 9 x 6 in., cloth. $2.50.

General Sibert has had a long, honorable career as an officer and an engineer. This life describes his engineering work in the Philippines, in charge of the Ohio river improvements, and in the building of the Gatun locks and dam and the Mobile ocean terminal. His activities as director of the Chemical Warfare Service during the World War and as Chairman of the Boulder Dam Board are also presented.

X-RAY CRYSTALLOGRAPHY.

By R. W. James. N. Y., E. P. Dutton & Co., 1930. 88 pp., diagrs., 7 x 4 in., cloth. $1.15.

A brief, up-to-date outline of the main principles that underly methods of analyzing crystals by means of X-rays, adapted as an introduction for those taking up the study seriously, or as a general account for students of other branches of physics.

Engineering Societies Employment Service

Under joint management of the national societies of Civil, Mining, Mechanical and Electrical Engineers cooperating with the Western Society of Engineers. The service is available only to their membership, and is maintained as a cooperative bureau by contribution from the societies and their individual members who are directly benefited.

Offices:—31 West 39th St., New York, N. Y.—W. V. Brown, Manager.
1216 Engineering Bldg., 205 W. Wacker Drive, Chicago, Ill., A. K. Krauser, Manager.
57 Post St., San Francisco, Calif., N. D. Cook, Manager.

MEN AVAILABLE—Brief announcements will be published without charge but will not be repeated except upon requests received after an interval of one month. Names and records will remain in the active files of the bureau for a period of three months and are renewable upon request. Notices for this Department should be addressed to ***EMPLOYMENT SERVICE, 31 West 39th Street, New York City,*** *and should be received prior to the 15th day of the month.*

OPPORTUNITIES.—A Bulletin of engineering positions available is published weekly and is available to members of the Societies concerned at a subscription of $3 per quarter, or $10 per annum, payable in advance. Positions not filled promptly as a result of publication in the Bulletin may be announced herein, as formerly.

VOLUNTARY CONTRIBUTIONS.—Members obtaining positions through the medium of this service are invited to cooperate with the Societies in the financing of the work by contributions made within thirty days after placement, on the basis of one and one-half per cent of the first year's salary: temporary positions (of one month or less) three per cent of total salary received. The income contributed by the members, together with the finances appropriated by the four societies named above will it is hoped, be sufficient not only to maintain, but to increase and extend the service.

REPLIES TO ANNOUNCEMENTS.—Replies to announcements published herein or in the Bulletin, should be addressed to the key number indicated in each case, with a two cent stamp attached for reforwarding, and forwarded to the Employment Service as above. Replies received by the bureau after the positions to which they refer have been filled will not be forwarded.

POSITIONS OPEN

ELECTRICAL ENGINEER, graduate, two to five years' practical experience for work on design, field tests and reports on underground power cable accessories. Cable experience not necessary. Design and test preferred. Large middle western utility. Apply by letter stating age, salary expected and experience in detail. W-1897.

MEN AVAILABLE

ELECTRICAL ENGINEER, 44, married. Six years electrical superintendent of 18,000-kw. steam plant. Seven years in charge Pacific Coast electrical inspections for largest machinery insurance company. A-1 references. Available immediately. C-8125-309-C-7.

GRADUATE ENGINEER, 22 years old, single, graduate in electrical engineering with B. S. degree. Location immaterial. Would be interested in South American position. C-8138.

ELECTRICAL ENGINEER, age 35, several years with design and construction corporation on electrical design, construction and specifications covering power plants, refrigerating plants, electrical drives for steel, copper and paper mills. Also several years with a large manufacturing company of electrical equipment, as general electrical engineer. B-3172.

METERMAN, 32, with G. E. factory test experience desires connection as foreman or assistant foreman of public utility electric meter department. Also experience as supervisor of large utility complaint and adjustment division. Western location preferred. C-8135-309-C-9.

1929 GRADUATE ELECTRICAL ENGINEER, 24, single, 14 months on General Electric Test Course. Desires location with utility or engineering work with manufacturing company in the South. Also interested in instructorship in a southern college. Hard worker. C-7881.

DISTRIBUTION ENGINEER, 37, eleven years' experience in distribution work. Desires position with public utility in East or Middle West. B-9248.

UTILITY, superintendent of operation, has demonstrated ability in this line for past six years with company having six thousand customers. Technical graduate. Desires position of similar character. Available at once. C-6971.

SALES ENGINEER, 32, single, graduate electrical engineer. G. E. test and engineering experience with large utility. Experienced in sale of line hardware, distribution, high-voltage and street lighting equipment, transmission conductors and lead cable. Available at once. Location preferred, Pacific Coast. B-2624-309-C-11.

ELECTRICAL ENGINEER, B. S. Degree, 33, Westinghouse sales course, 15 months sales assistant, three years technical advertising, four and one-half years' development, sales surveys on oil-electric locomotives. Executive ability. Desires sales position electric traction or industrial electrical equipment or engineering with railroad electric traction department. References. Location, will consider. C-7545.

TECHNICAL GRADUATE, 33, married. Ten years in industrial plant design, construction, maintenance and power. Thoroughly familiar with modern steam generation for power and process work, the application of electrical equipment and air conditioning. Desires position in charge, assistant in charge or other responsible position in the engineering department of an industrial plant. C-8140.

GRADUATE ELECTRICAL ENGINEER, experienced on testing, developmental manufacturing, electrical plant construction. Wide experience all features design of power stations, indoor and outdoor substations and industrial light and power. Checker two years. Squad leader two years. Will consider any location. B-9222.

TECHNICALLY TRAINED ELECTRICAL ENGINEER, 29, married, English. Three years Electrical Department, English railroad. One year electric locomotive design Swiss manufacturing firm, Switzerland. Three years American Copper Mining Co., Chile. Now holding position, superintendent of power. Chilean utility company. Desires change of position preferably abroad. Speaks Spanish, French. Available one month's notice. C-8190.

AN EXECUTIVE AND SALES ENGINEER with twenty years of broad experience with gas engine manufacturing, sales of power equipment and special electrical equipment, to Western Utilities will be available January 1st. Particularly familiar with Western Engineering and sales conditions. C-8014.

ELECTRICAL ENGINEER, single, 30, Scandinavian, graduate Swiss Federal Institute of Technology, Zurich, with 6½ years' experience, four in U. S. with manufacturing, mining, public utility and sugar companies, including operation, test, layout, estimate, inspection, drafting, and design. Desires permanent position with future. Speaks German and Spanish. C-3764.

EXECUTIVE, production engineer, cost expert, cost accountant with knowledge of budget control, practical, technical, commercial instruments; telephones, printing, machinery, pressed steel wave enamel, stainless steel, tinned and galvanized. Thirty years' experience. C-3241.

RECENT GRADUATE, electrical engineer; married; age 24. Location, Northern United States. Available December 1st. C-7975.

ELECTRICAL ENGINEER, graduate, 30, single. Eight years' experience with public utility, contractor, consulting engineer and electrical manufacturers; designing, estimating, specifying and selling. Languages, German and French. New York and vicinity preferred. C-4758.

SALES ENGINEER, three years' experience, metal flux used in brass foundries. Large acquaintance in non-ferrous casting industry. Familiar with foundry practise and methods, both technical and practical. Knowledge of chemistry as applied to alloys. Engineering design ability. Valuable on sales and service work with material or equipment used in manufacturing castings. B-5207.

ELECTRICAL MECHANICAL ENGINEER, graduate, 36, twelve years' comprehensive experience designing, general engineering details modern power plants, substations. Exceptionally versed designing control, protective wiring generators, transformers, switching apparatus, transmission lines, automatic substations. Two years with Westinghouse Company, four years with another nationally known engineering firm. Desires position with public utility, consulting engineer, industrial concern. C-8195.

ENGINEER, EXECUTIVE, B. S. degree. Twenty years' experience in engineering contracting and purchasing. Desires permanent connection with large industrial company or as a local representative. Location, New York City. B-5050.

GRADUATE ELECTRICAL ENGINEER, 22, B. S. at Worcester Polytechnic Institute. Sixteen months on General Electric Test. Desires position with opportunity for advancement with utility, manufacturing, or other engineering firm. Location preferred, New England or East. C-8075.

MANAGER, EXECUTIVE ENGINEER, SUPERINTENDENT, CONSULTANT, SALES ENGINEER, 41, assistant to major executive. Electrical utility properties, management organizations, industrials, manufacturers. Broadly trained 20 years of diversified responsibilities, five connections. Demonstrated ability large projects. Sound economical design, construction, operation. Extensive changeover programs, networks, underground systems. Vitally

energetic, American. Early change imperative. Salary not immediate objective. C-3963.

ELECTRICAL ENGINEER, 27, experienced in public utility surveys, electric distribution engineering, load-building activities and sales. Desires work as line superintendent, assistant to senior electrical engineer or manager or will consider good opportunity for advancement in any phase of hydroelectric development. Available on two weeks' notice. C-7819.

ELECTRICAL GRADUATE, B. S. degree, 31, single; 14 years' public utility experience five different corporations, covering supervision of underground layouts, conversion of overhead to underground, research work, reports on electrolytic conditions on cables, construction estimates. Designing underground and overhead system. Executive ability. Desires permanent position growing organization. Available at once. C-8163.

DISTRIBUTION AND PLANNING ENGINEER, E. E., 34 years old, married, desires immediate engagement. Professional career covers two years of field construction with engineers and contractors; two years' designing and estimating on industrial, loft, and apartment buildings; one year of station and substation design, and five years of distribution engineering. C-658.

ELECTRICAL ENGINEER, 27, with general utility and manufacturing test, together with telephone manufacturing planning experience. Desires position in planning or testing. Location, East or Middle West. C-8189.

DRAFTSMAN-DESIGNER, graduate in electrical and mechanical engineering from two foreign colleges. Familiar with motors, transformers and induction voltage regulators. Age 29; 6 years' experience. Best references; permanent position. C-398.

GRADUATE ELECTRICAL ENGINEER (M. S.), thoroughly grounded in fundamentals; experience involves 3½ years test work mainly on central station equipment and 3 years of experimental and development work including static condensers and transformers. At present employed but will consider an opening with a future. B-9927.

GRADUATE, 1928, with B. S. in electrical engineering. Single, 24, twenty-three months on General Electric Test Course. Desires location in industrial, railway electrification, or central station fields or as assistant to consulting engineer. Available at once. Location, east of the Mississippi. C-4583.

1930 GRADUATE ELECTRICAL ENGINEER, single, 24. Desires engineering work of any nature with opportunity for advancement. Can furnish best of references. Location, Middle West, in or near Chicago preferred. C-8245.

SALES ENGINEER, age 48, twenty-one years' experience selling general line of large and small equipment as manufactured by one of the largest electrical manufacturing companies. Prefers working in Rocky Mountain States where past experience was obtained, but will go anywhere. Qualified to handle commercial job in public utility. Available now. C-8246.

EXECUTIVE having comprehensive experience in the promotion and financing of engineering developments especially abroad. Successful record in negotiating concessions and contracts with Government Officials. Now associated with New York firm of engineers and bankers. American born; graduate E. E.; married; 41. Speaks Spanish, knowledge French, German. C-3968.

ELECTRICAL ENGINEER, with 15 years' experience in design, construction, reports and editorial work. Now engaged on special publishing job. Will be available November 1st for publicity or editorial work on trade publications. References with leading engineering and publishing firms can be furnished. B-4022.

ENGINEER-EXECUTIVE, 18 years' engineering and financial experience. Public Utility executive. Engineering investigations and reports on electric power developments. Application of electric power to manufacturing and mining. B-5291.

SALES ENGINEER, electrical and mechanical training at Worcester Polytechnic Institute. One year manufacturing, five years' sales and executive experience. Would like opportunity to develop sales or assist in sales management. C-5431.

GRADUATE ELECTRICAL ENGINEER, married, 28, four and a half years' experience as designer of electrical indicating instruments. Qualified to take charge of development and design small electrical apparatus. B-9583.

ELECTRICAL ENGINEER, 27, married, E. E. degree, Lehigh University. Three years' cadet course with large eastern utility, two years, electrical engineering department of engineering and construction company. Familiar design of lighting and power for industrial plants, public buildings, all phases of public utility work. Employed at present. Desires permanent responsible position. C-8250.

ELECTRICAL ENGINEER, age 28, one year standardizing laboratory, calibrating and testing of instruments. One year research and acceptance tests on automatic network equipment for distribution system. Seven years research test and inspection of electrical equipment in power plants. One year layout and design of electrical equipment for bridges. B-9349.

ELECTRICAL DESIGNER, 8 years' experience on power plants, substation and high tension projects, desires connection with public utility or industrial organization. Experience includes work on preparation of voltage and load studies. Age 31, single, but with dependents. Has equivalent of college education. Sales work considered. Available on short notice. C-254.

ELECTRICAL ENGINEER, graduate Union College 1924, age 28, married; good appearance, 2 years telephone maintenance, 15 months General Electric Test course, 4 years public utility operation. 15 years, non-commercial radio experience. Location, East. Available at once. C-4182.

1929 GRADUATE ELECTRICAL ENGINEER, 22, single; 15 months on General Electric test course. Desires location with utility or manufacturing company or with concern doing consulting or construction engineering. Available immediately. Location, New England preferred. C-8028.

GRADUATE ELECTRICAL ENGINEER; 17 years' experience in electrical manufacturing; electric railway, power plant, substation and transmission line design and construction, desires connection with real opportunity. C-8256.

ELECTRICAL-MECHANICAL ENGINEER, 15 years' practical experience as electrical, plant, efficiency, research, resident, testing engineer; designer where initiative, originality and practicability were essential. Contributed worthy technical articles and inventions. Valuable to consulting engineer, architects where changes in personnel are anticipated. Good leader due to wide experience. Licensed professional engineer. B-5675.

SALES ENGINEER, 27, single, graduate Georgia Technology in E. E. With largest manufacturer storage batteries 2½ years selling to utilities and contracting industrial engineers. Desires connection sales department of electrical business manufacturing best in its line. Will also consider manufacturer's agency Atlanta or Birmingham. Available November. Location preferred, South. C-8273.

ELECTRICAL-INDUSTRIAL ENGINEER, 28, married, wishes position as assistant to executive or as member of staff of consulting engineers. Two years' Westinghouse student course, three years' utility construction and reports on economic studies and one year and a quarter as management engineer making industrial surveys with consultants. Location, immaterial. C-7695.

ELECTRICAL ENGINEER, 28, married. Four years' substation and power house operation and maintenance experience. Thorough knowledge of rate structure and application. One and a half years' telephone and telegraph engineering of transmission problems, circuit arrangements, traffic studies. Executive ability. Available now. C-5682.

RESEARCH, DEVELOPMENT ENGINEER, 38, married. B. S. degree in E. E. M. S. physics. Five years teaching. Five years journeyman electrician, mechanic. Two years development engineer Bell Telephone System. Two years research, development engineer for large maker X-ray, therapeutic apparatus. Desires position where experience will be valuable. Available on fifteen days' notice. C-2677.

MEMBERSHIP—Applications, Elections, Transfers, Etc.

RECOMMENDED FOR TRANSFER

The Board of Examiners, at its meeting of October 21, 1930, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the National Secretary.

To Grade of Fellow

JOLLYMAN, JOSIAH P., Chief of Division of Hydroelectric & Transmission Engg., Pacific Gas & Electric Co., San Francisco, Calif.

NOTTORF, WILLIAM E. A., Vice-President, American Electric Co., Inc., Chicago, Ill.

SPORN, PHILIP, Chief Elec. Engr., American Gas & Elec. Co., New York, N. Y.

WHITING, DONALD F., Technical Director, Fox Hearst Corp., New York, N. Y.

WILKINSON, KENNETH L., General Operating Results Engr., American Tel. & Tel. Co., New York, N. Y.

To Grade of Member

AUBREY, CHARLES A., Engineer, General Elec. Co., Cleveland, Ohio.

BOWMAN, CLAIR F., Asst. Prof., Montana State College, Bozeman, Montana.

CHITTY, Wm. C., Electrical Engr., Alhambra, Calif.

CROWLEY, JOHN C., Engr., Electrical Research Products, Inc., New York, N. Y.

DEXTER, B. D., Elec. Engr., Pacific Gas & Elec. Co., San Francisco, Calif.

GLASSE, ALFRED O., Chief Engr., Auckland Elec. Power Board, Auckland, N. Z.

HANKS, ALFRED J., Engr., Western Union Telegraph Co., New York, N. Y.

HASKELL, MOSES E., Supt. Engr., Morarjee Goculdas Co., Bombay, India.

HINRICHS, ERNST, Mechanical and Electrical Engr., The Fresnillo Co., Zacatecas, Mexico.

MINASIAN, GEORGE T., Distribution Engr., N. Y. Edison Co., New York, N. Y.

MIRICK, HARRY L., Equipment Engg. Supervisor, American Tel. & Tel. Co., New York.

PEARCY, NOAH C., Asst. Elec. Engr., Byllesby Engg. & Mgt. Corp., Chicago, Ill.

PIERCE, RALPH E., Engr., American Tel. & Tel. Co., New York, N. Y.
POPE, HARRY M., Engr., American Tel. & Tel. Co., New York.
ROBINSON, EDMUND L., Factory Manager, Crescent Insulated Wire & Cable Co., and Crescent Armored Wire Co., Trenton, N. J.
RUSSELL, SAMUEL P., Vice-President, H. B. Squires & Co., San Francisco, Calif.
SHOESTER, GEORGE W., Representative, Electrical Research Products, Inc., New York.
SOARES, E. C., Consulting Engr., The R. B. Engg. Corp., New York.
STROBEL, CHARLES K., Research Engr., Union Switch & Signal Co., Swissvale, Pa.
THOMPSON, HARRY E., Asst. Engr., Brooklyn Edison Co., Brooklyn, N. Y.
WALSH, FRANK, Manager, Northeastern District, Puget Sound Pr. & Lt. Co., Everett, Wash.
YOUNG, FREDERIC C., Development Engr., Stromberg-Carlson Tel. Mfg. Co., Rochester, N. Y.

APPLICATIONS FOR ELECTION

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before November 30, 1930.

Alley, K. G., Central Illinois Public Service Co., Marion, Ill.
Bodisco, M. A., Bethlehem Shipbuilding Co., Ltd., San Francisco, Calif.
Bolster, A. L., Toledo Edison Co., Toledo, Ohio
Brentnall, E. L., W. R. Hendrey Co., Seattle, Wash.
Brobst, D. R., (Member), Bell Telephone Labs., Inc., New York, N. Y.
Brosemer, R. O., General Electric Co., San Francisco, Calif.
Brown, H. M., Pennsylvania Power & Light Co., Northampton, Pa.
(Applicant for re-election)
Brown, W. F., Toledo University, Toledo, Ohio
Chapman, N. M., General Electric Co., Fort Wayne, Ind.
Choate, W. H., Electric Power Equipment, Ltd., Vancouver, B. C., Can.
Cliver, E. K., Drexel Institute, Philadelphia, Pa.
Clower, W. M., Clower Electric Co., Dallas, Tex.
Collins, H. L., Reliance Electric & Engineering Co., Cleveland, Ohio
Concordia, C., General Electric Co., Schenectady, N. Y.
Curtis, E. C., General Electric Co., Portland, Ore.
Demmings, H. L., Lynn Gas & Electric Co., Lynn, Mass.
Dietsch, A. J., P. O. Box 345, Dedham, Mass.
Edwards, H. H., New York Telephone Co., Mt. Vernon, N. Y.
Einfalt, C. R., Stone & Webster Engg. Corp., Hopewell, Va.
Farrer, S., Ferguson Pailin Ltd., Manchester, Eng.
Ferris, R. T., Associated Gas & Electric Co., Brewster, N. Y.
Figentzer, T., 1185 Second Ave., New York, N. Y.
Flynn, R. H., *Electrical West*, San Francisco, Calif.
Francis, B. H., Bell Telephone Laboratories, New York, N. Y.
Frey, W. T., 131 West St., Reno, Nevada
Greene, C. E., (Member), Metcalf & Eddy, Boston, Mass.
Griffin, P. O., General Electric Co., Toledo, Ohio
Herren, W. M., Southwestern Bell Telephone Co., Kansas City, Mo.
Hirsch, H., 1056 Boston Road, New York, N. Y.
Holland, H. E., United Electric Supply Co., Salt Lake City, Utah
Hunt, J. H., Toledo Edison Co., Toledo, Ohio
Jenkins, P. R., American Tel. & Tel. Co., Denver, Colo.
Killam, K. A., General Electric Co., Fort Wayne, Ind.
King, C. A., 1760 Haight St., San Francisco, Calif.
Kohlmeier, R. W., Associated Gas & Electric Co., Elmira, N. Y.
Krenz, E. J., Pacific Tel. & Tel. Co., San Francisco, Calif.
Mason, M. S., (Member), American Tel. & Tel. Co., New York, N. Y.
Meigs, P. F., Bucyrus Erie Co., South Milwaukee, Wis.
Missonellie, S., 308 Goffle Rd., Hawthorne, N. J.
Mitchell, C. W., (Member), Board of Fire Underwriters of the Pacific, San Francisco, Calif.
Morgan, R., Westinghouse Electric International Co., New York, N. Y.
Morrison, F. W., New York Edison Co., New York, N. Y.
Muggli, J. H., (Member), Shell Oil Co., Martinez, Calif.
Myers, G. A., United Light & Power Engineering & Construction Co., Kansas City, Mo.
Nash, D. O., General Cable Corp., Atlanta, Ga.
Nolen, J. T., Jr., (Member), Alabama Power Co., Huntsville, Ala.
Ogden, C., The Canadian Laundry Machinery Co., Ltd., Toronto, Ont., Can.
Olmstead, I. L., Columbia Steel Co., Portland, Ore.
(Applicant for re-election)
Piersol, J. M., Aluminum Co. of America, Philadelphia, Pa.
Porter, N. M., Southwestern Bell Tel. Co., Oklahoma City, Okla.
Price, W. S., Southwestern Bell Tel. Co., Kansas City, Mo.
Prosser, R. A., Board of Education, Buffalo, N. Y.
Reine, J., Graybar Electric Co., Inc., Seattle, Wash.
Rhein, C. C., General Electric Co., Schenectady, N. Y.
Scanlan, H. J., Hudson Bay Co., Vancouver, B. C., Can.
Schlosser, W. H., Dominion Electric Power Ltd., Regina, Sask., Can.
Shine, L. J., Tobe Distributing Co., New York, N. Y.
Speaker, J. W., (Fellow), American Gas & Machine Co., Albert Lea, Minn.
Stafford, J. W., (Member), Purdue University, Lafayette, Ind.
Tome, W. C., Lighting Div., City Hall; Walbrook Electric Co., Baltimore, Md.
Van der Dussen, J., Brooklyn Edison Co., Brooklyn, N. Y.
Weathers, L. C., University of Colorado, Boulder, Colo.
White, T., Jr., Union Electric Light & Power Co., St. Louis, Mo.
Whitwam, L. F., Box 73, Los Altos, Calif.
Winkelman, L. A., Public Service Elec. & Gas Co., Newark, N. J.
Zupa, D. A., Electrical Research Products, Inc., New York, N. Y.
Total 66

Foreign

Dayal, R., Public Works Dept., Race-View, Simla, India
Gautam, S., Engineer, Alwar State, India
Howell, C. B., (Fellow), Fabric de Cimento Portland de Mocambique, Lourenco Marques, P. East Africa
Koudyrsky, A. R., (Member), Installation of Dnieprostroi, Leningrad, U. S. S. R
Levenson, N. I., (Member), Dnieprostroi, Leningrad, U. S. S. R.
Tokuda, T., Tokyo Electric Light Co., Tokyo, Japan
Wagner, R. R., (Member), Electro-Mechanical Dept., Kichkas, Dnieprostroi, U. S S. R.
Winter, A. V., (Member), Dnieprostroi Development, Karuninskaia, Moscow, U. S. S. R.
Total 8

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F. M. Servos, Rio de Janiero Tramways, Light & Power Co., Rio de Janeiro, Brazil.
A. P. M. Fleming, Metropolitan Vickers Elec. Co., Trafford Park, Manchester, England.
A. S. Garfield, 173 Boulevard Haussmann, Paris 8 E., France.
Renzo Norsa, Via Caravaggio 1, Milano 25, Italy.
P. H. Powell, Canterbury College, Christchurch, New Zealand.
M. Chatelain, Lesnoi Polytechnic Institute, Apt. 27, Leningrad, U. S. S. R.
Axel F. Enstrom, 24a Ingeniorsvetenskrapsakademien, Stockholm, 5 Sweden.
W. Eldson-Dew, P. O. Box 4563 Johannesburg, Transvaal, Africa.

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(A list of the personnel of Institute committees may be found in the September issue of the Journal.)

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Safety Codes, A. W. Berresford
Engineering Profession, H. A. Kidder
Columbia University Scholarships, W. I. Slichter
Popular Science Award, A. E. Knowlton
Advisory Committee to the Museum of the Peaceful Arts, J. P. Jackson

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Electrophysics, O. E. Buckley
General Power Applications, C. W. Drake
Instruments and Measurements, E. J. Rutan
Applications to Iron and Steel Production, A. C. Cummins
Production and Application of Light, George S. Merrill
Applications to Marine Work, R. A. Beekman
Applications to Mining Work, Carl Lee
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Power Transmission and Distribution, P. H. Chase
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Transportation, Sidney Withington

A. I. E. E. REPRESENTATION

(The Institute is represented on the following bodies; the names of the representatives may be found in the September issue of the Journal.)

Alfred Noble Prize Committee, A. S. C. E.
American Association for the Advancement of Science, Council
American Bureau of Welding
American Committee on Electrolysis
American Engineering Council Assembly
American Marine Standards Committee
American Standards Association
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Charles A. Coffin Fellowship and Research Fund Committee
Committee of Apparatus Makers and Users, National Research Council
Committee on Elimination of Fatigue, Society of Industrial Engineers
Committee on Heat Transmission, National Research Council
Engineering Foundation, Inc.
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National Research Council, Engineering Division
National Safety Council, Electrical Committee of A. S. S. E.—Engineering Section
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U. S. National Committee of the International Commission on Illumination
U. S. National Committee of the International Electrotechnical Commission
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No. 1—North Eastern	I. E. Moultrop, Edison Elec. Illum. Co. of Boston, 39 Boylston St., Boston, Mass.	A. C. Stevens, General Electric Co., Schenectady, N. Y.
No. 2—Middle Eastern	E. C. Stone, Duquesne Light Co., 435 Sixth Ave., Pittsburgh, Pa.	J. A. Cadwallader, Bell Tel. Co. of Penna., 416 Seventh Ave., Pittsburgh, Pa.
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No. 5—Great Lakes	T. N. Lacy, Michigan Bell Tel. Co., 1365 Cass Ave., Detroit, Mich.	A. G. Dewars, Northern States Power Co., 15 S. 15th St., Minneapolis, Minn.
No. 6—North Central	Herbert S. Evans, University of Colorado, Boulder, Colo.	M. S. Coover, University of Colorado, Boulder, Colo.
No. 7—South West	G. C. Shaad, University of Kansas, Lawrence, Kans.	Robert W. Warner, University of Kansas, Lawrence, Kans.
No. 8—Pacific	C. E. Fleager, Pacific Tel. & Tel. Co., 140 New Montgomery St., San Francisco, Calif.	H. W. Hitchcock, 1050 Telephone Building, 740 South Olive St., Los Angeles, Calif.
No. 9—North West	H. V. Carpenter, State College of Washington, Pullman, Wash.	R. D. Sloan, State College of Washington, Pullman, Wash.
No. 10—Canada	C. E. Sisson, Canadian General Electric Co., 1025 Lansdowne Ave., Toronto, Ont.	W. L. Amos, Hydro-Elec. Power Commission, 190 University Ave., Toronto, Ont.

Note: Each District Executive Committee includes the chairmen and secretaries of all Sections within the District and the chairman of the District Committee on Student Activities.

LIST OF SECTIONS

Name	District	Chairman	Secretary
Akron	(2)	H. C. Paiste	Alvin P. Regal, Phila. Rubber Works Co., Akron, Ohio
Atlanta	(4)	H. C. Uhl	O. O. Rae, Westinghouse Elec & Mfg. Co., Atlanta, Ga.
Baltimore	(2)	W.B.Kouwenhoven	J. Wells, Western Electric Co., 25 Broening Rd., Baltimore, Md.
Birmingham	(4)		O. E. Charlton, Alabama Power Co., Birmingham, Ala.
Boston	(1)	J. P. Kobrock	G. J. Crowdes, Simplex Wire & Cable Co., Sidney St., Cambridge, Mass.
Chicago	(5)	F. H. Lane	L. R. Mapes, Illinois Bell Telephone Co., 212 W. Washington St., Chicago, Ill.
Cincinnati	(2)	T. C. Reed	L. L. Bosch, Columbia Engg. & Mgt. Corp., 314 West 4th St., Cincinnati, Ohio
Cleveland	(2)	F. W. Braund	John M. Smith, Nela Park, Cleveland, Ohio
Columbus	(2)	C. D. Price	K. Y. Tang, Ohio State University, Columbus, Ohio
Connecticut	(1)	Samuel Ferguson	R. G. Warner, Yale University, 10 Hillhouse Ave., New Haven, Conn.
Dallas	(7)	L. T. Blaisdell	G. A. Dyer, Southwestern Bell Telephone Co., Dallas, Texas
Denver	(6)	R. B. Bonney	N. R. Love, 807 Tramway Bldg., Denver, Colo.
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Erie	(2)	G. R. McDonald	G. I. LeBaron, General Elec. Co., Erie, Pa.
Fort Wayne	(5)	W. J. Morrill	C. M. Summers, General Elec. Co., Fort Wayne, Indiana
Houston	(7)	C. D. Farman	Hezzie Clark, 2012 Melrose St., Houston, Texas
Indianapolis-Laf.	(5)	E. G. Ralston	C. E. Dutton, American Tel. & Tel. Co., 256 N. Meridian St., Indianapolis, Ind.
Iowa	(5)	J. K. McNeely	H. B. Hoffhaus, Des Moines Elec. Lt. Co., 312-6th Ave., Des Moines, Iowa
Ithaca	(1)	W. C. Ballard, Jr.	W. E. Meserve, 614 E. Buffalo St., Ithaca, N. Y.
Kansas City	(7)	J. S. Palmer	Bruce E. Dolch, 932 Board of Trade Bldg., Kansas City, Mo.
Lehigh Valley	(2)	W. M. Harbaugh	J. H. Diefenderfer, Pennsylvania Pr. & Lt. Co., Hazleton, Pa.
Los Angeles	(8)	H. W. Hitchcock	Philip S. Biegler, 3551 University Ave., Los Angeles, Calif.
Louisville	(4)	James Clark, Jr.	Philip P. Ash, Louisville & Nashville Rd. Bldg., 9th and Broadway Ave., Louisville, Ky.
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Madison	(5)	L. C. Larson	G. F. Tracy, Elec. Lab. Bldg., University of Wisconsin, Madison, Wis.
Memphis	(4)	M. Eldredge	W. A. Gentry, Memphis Pr. & Lt. Co., Memphis, Tenn.
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Nebraska	(6)	W. O. Jacobi	A. L. Turner, 1112 Telephone Bldg., Omaha, Nebraska
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North Carolina	(4)	E. P. Coles	Marshall E. Lake, Duke Power Co., Power Bldg., Charlotte, No. Car.
Oklahoma City	(7)	F. J. Meyer	C. E. Bathe, Oklahoma Gas & Elec. Co., Oklahoma City, Okla.
Philadelphia	(2)	D. H. Kelly	J. L. MacBurney, Electric Storage Battery Co., 1955 Hunting Park Ave., Philadelphia, Pa.
Pittsburgh	(2)	C. T. Sinclair	F. A. Connor, General Elec. Co., 1309 Oliver Bldg., Pittsburgh, Pa.
Pittsfield	(1)	C. H. Kline	L. H. Burnham, General Electric Co., Pittsfield, Mass.
Portland, Ore.	(9)	A. H. Kreul	C. W. Fick, General Electric Co., Portland, Oregon
Providence	(1)	J. W. Young	O. W. Briden, Blackstone Valley Gas & Elec. Co., 231 Main St., Pawtucket, R. I.
Rochester	(1)	Harvey J. Klumb	F. C. Young, Stromberg-Carlson Tel. Mfg. Co., 100 Carlson Rd., Rochester, N. Y.
St. Louis	(7)	C. B. Fall	E. A. Forkner, Wagner Elec. Corp., 6400 Plymouth Ave., St. Louis, Mo.
San Antonio	(7)	D. W. Flowers	Eugene Bissett, San Antonio Pub. Serv. Co. 201 N. St. Mary's St., San Antonio, Texas
San Francisco	(8)	P. B. Garrett	E. F. Maryatt, Pacific Gas & Elec. Co., 245 Market St., San Francisco, Calif.
Saskatchewan	(10)	W. T. Hunt	A. B. Coward, Light and Power Dept., Regina, Sask. Canada
Schenectady	(1)	E. S. Henningsen	E. P. Nelson, D. C. Engg. Dept., General Electric Co., Schenectady, N. Y.
Seattle	(9)	C. E. Carey	Philip D. Jennings, Puget Sound Pr. & Lt. Co., 7th and Olive Sts., Seattle, Wash.
Sharon	(2)	S. S. Cook	R. M. Field, Westinghouse Elec. & Mfg. Co., Sharon, Pa.
Southern Virginia	(4)	J. H. Berry	Cecil Gray, Westinghouse Elec. & Mfg. Co., 912 Electric Bldg., Richmond, Va.
Spokane	(9)	Loren A. Traub	C. F. Norberg, Washington Water Power Co., Spokane, Wash.
Springfield, Mass.	(1)	J. N. Alberti	L. C. Packer, Westinghouse Elec. & Mfg. Co., Page Blvd., Springfield, Mass.
Syracuse	(1)	F. E. Verdin	Charles W. Henderson, 504 University Pl., Syracuse, N. Y.
Toledo	(2)	F. H. Dubs	Max Neuber, 1257 Fernwood Ave., Toledo, Ohio
Toronto	(10)	D. A. McKenzie	G. D. Floyd, Hydro Electric Pr. Comm., 190 University Ave., Toronto, Ont., Canada
Urbana	(5)	C. E. Skroder	W. J. Putnam, 123 Mat. Test. Lab., University of Illinois, Urbana, Ill.
Utah	(9)	L. B. Fuller	Paul Ranson, Utah Apex Mining Co., Bingham Canyon, Utah
Vancouver	(10)	H. Vickers	C. Arnott, B. C. Electric Railway Co., Ltd., 425 Carrall St., Vancouver, B. C. Canada
Washington	(2)	George W. Vinal	J. L. Carr, General Elec. Co., 800-15th St. N. W., Washington, D. C.
Worcester	(1)	J. K. Oldham	R. P. Bullen, c/o General Elec. Co., Worcester, Mass.

Total 58

LIST OF BRANCHES

Name and Location	District	Chairman	Secretary	Counselor (Member of Faculty)
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High-Voltage Insulators.—Bulletin 579H, 32 pp., "Highlights." Describes the evolution of various types of O-B high voltage, pin type, porcelain insulators, and includes illustrations of early applications. Ohio Brass Co., Mansfield, Ohio.

Illumination for Night Sports.—Bulletin GEA-1206, 12 pp., "The Light that Started Sports at Night." Includes illustrations of night sporting events made possible by G-E Novalux Projectors. General Electric Co., Schenectady, N. Y.

Motors.—Bulletin 200, 8 pp. Describes "Ideal" unit type induction motors. Rotor and stator units are interchangeable, as well as end brackets, anti-friction bearings and bases. Ideal Electric & Manufacturing Co., Mansfield, Ohio.

High Voltage Cables.—Bulletin 155A, 40 pp., entitled "Super Tension Cables." Describes various types of high voltage cables, including submarine power cables of exceptional length. Installations are illustrated. Siemens Brothers & Co., Ltd., London, S. E. 18, England.

Metering Devices.—Catalog 100, 36 pp. Describes test switches, test blocks and a complete line of meter testing devices. A number of wiring diagrams entailing the use of these accessories are included, as well as illustrations of typical installations. Meter Devices Company, Canton, Ohio.

Resistances.—Bulletin, 10 pp. Describes Allegheny "Ohmaloy," a wrought chrome iron alloy developed by Allegheny Steel Company and a new development in the resistance wire field having application in the manufacture of radio parts, such as rheostats, grid resistances, resistors, etc. It is supplied in all sizes of round wire, bare or covered, and in sheet and ribbon form. The Gilby Wire Company, Newark, N. J., are authorized fabricators of the alloy in the forms of wire and strip.

Demand Meter.—Bulletin 80, 16 pp. Describes the new type "S" Sangamo kv-a. demand meter. This meter is an auxiliary device controlled by two watthour meters, measuring the energy and reactive component, to give, on a single chart, the following information relative to the load: the kv-a. demand, kw. demand, maximum kw. demand, power-factor at time of demand, reactive component demand, the time that the demand occurred, the energy component in kilowatthours and the reactive component in reactive kilovolt-amperehours. The meter has been in service on a number of important industrial installations and has performed very satisfactorily. Sangamo Electric Company, Springfield, Ill.

NOTES OF THE INDUSTRY

G. E. to Erect Million Dollar Building at Pittsfield.—Plans for a new manufacturing building to cost $1,000,000 to be erected at the Pittsfield plant of the General Electric Company immediately, have been announced by E. A. Wagner, general manager of the works. The structure will be devoted to the exclusive manufacture of transformer tanks. It will be more than 550 feet long, 150 feet wide and 70 feet high, and will be all welded—probably the largest welded building of its kind. Construction will take nearly four months. Present construction plans provide that the entire building will be built of steel and glass on a concrete foundation. In connection with the main building there will also be an extension, 350 feet long by 27 feet wide to be used for the various manufacturing and production offices. This will be similar to the main building with respect to construction details.

National Carbon Company in Lubrication Field.—Beginning November 1, 1930 the entire line of "Gredag" lubricants manufactured by the Acheson Graphite Corporation, a unit of the Union Carbide and Carbon Corporation will be distributed and sold by the Carbon Sales Division of National Carbon Company, Inc., with headquarters at Cleveland, Ohio. The Carbon Sales Division of National Carbon Company has been active for many years in the sales and distribution of carbon, graphite and metal graphite brushes, illuminating carbons, welding carbons and numerous carbon specialties of importance to many industries. The addition of "Gredag" to the products of the Carbon Sales Division is considered a most logical step by National Carbon Company because this division of the company is in continuous contact with industrial plants and distributors of industrial products throughout the country.

Portable Oil Testing Laboratory.—An oil testing set, providing all the advantages of a laboratory, but of such size that it may be placed in any passenger car and taken into the field, is announced by the American Transformer Company, of Newark, N. J. The new oil tester, known as the AmerTran TS-6A, is completely housed in a 13½ in. by 14 in. by 18¾ in. rugged metal case which may be shipped without further crating. It operates from a standard 110-volt, 50/60-cycle supply and consists of a transformer, voltmeter, potentiometer, circuit breaker, oil cup, pilot light, and power switch. The weight of the complete equipment has been reduced to the point which permits one man to lift it. Foolproof construction and high accuracy are the two important features claimed for this test set. The dry-type testing transformer used in the set is capable of developing a potential of 30,000 volts at 0.5 kv-a.

A New Rubber Cable Insulation.—The Simplex Wire & Cable Company, of 201 Devonshire St., Boston, Mass., has recently announced a new type of rubber insulation called "Anoroc" which entirely does away with corona and ozone troubles on high voltage cables insulated with rubber compounds. "Anoroc" insulation is not claimed to be ozone proof, ozone repelling or ozone resisting. It goes at the problem from another angle. "Anoroc" (corona from another angle) absolutely prevents the formation of ozone in or about a cable at normal operating voltage, making all ozone proof or ozone resisting qualities superfluous, according to the manufacturer. It removes the only objection to rubber insulation for high voltage conductors and retains all of the electrical, chemical and physical characteristics which have made rubber the most adaptable and desirable insulation for cables. The efficacy of this method of protecting cable insulation from ozone has been amply demonstrated by laboratory tests fully substantiated by actual service under operating conditions. Details of tests are contained in a recent Simplex publication entitled "Corona Prevention and Ozone Elimination."

Large Transformer Order for Allis-Chalmers.—Allis-Chalmers Manufacturing Company, Milwaukee announces the receipt of order from West Virginia Hydro Electric Company, a subsidiary of the Union Carbide and Carbon Corporation, covering ten large power transformers amounting to approximately $500,000. This is the second order recently received by Allis-Chalmers from this company. The previous order covering two welded steel surface condensers for use with 30,000 kv-a. steam turbines.